REPORT NO: CG-D-12-84

(12)

AD-A141 759

AIRSHIP PROOF-OF-CONCEPT EVALUATION

H.G. KETCHEN

U.S. Coast Gua: : Research and Development Center
Avery Point Groton, Connecticut 06340

May 1984

Interim Report

Document is available to the U.S. Public through the
National Technical Information Service
Springfield, Virginia 22161

PREPARED FOR
U. S. DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

84 06 04 014

OFFICE OF RESEARCH AND DEVELOPMENT
WASHINGTON D.C. 20593

N O T I C E

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein soley because they are considered essential to the object of this report.

The contents of this report reflect the views of the Coast Guard Research and Development Center, which is responsible for the facts and accuracy of data presented. This report does not constitute a standard , specification, or regulation.

SAMUEL F. POWEL, III
Technical Director
U.S. Coast Guard Research and Development Center
Avery Point, Groton, Connecticut 06340

Technical Report Documentation Page

1. Report No. CG-D-12-84	2. Government Accession No. ADA141759	3. Recipient's Catalog No.
4. Title and Subtitle AIRSHIP PROOF-OF-CONCEPT EVALUATION		5. Report Date May 1984
		6. Performing Organization Code
7. Author(s) H.G. KETCHEN		8. Performing Organization Report No. CGR&DC 4/84
9. Performing Organization Name and Address U.S. Coast Guard Research and Development Center Avery Point Groton, CT 06340		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address Department of Transportation U.S. Coast Guard Office of Research and Development Washington, DC 20593		13. Type of Report and Period Covered Interim Report August 1983
		14. Sponsoring Agency Code

15. Supplementary Notes This report documents the Coast Guard R&D Center's portion of a three-month cooperative effort by the Coast Guard, Navy and NASA to evaluate the operational and technical performance of a modern airship. A final report on the entire cooperative effort is being produced by the Naval Air Development Center.

16. Abstract

During the week of 22 August 1983, the U.S. Coast Guard R&D Center conducted field tests off Oregon Inlet, NC, to evaluate the small target detection capability of lookouts on board an airship of modern design and materials and the potential advantages in the use of this type of platform for marine science activities (MSA) in support of a variety of Coast Guard missions. Visual searches were conducted for small orange-canopied life rafts (4- to 6-man) and simulated persons in the water. MSA experiments investigated the airship's capability to interface with the ocean including air and water sampling from the ocean surface and near surface, remote sensing, and air deployment/recovery of current measuring devices and other instruments. Target and airship positions were monitored with a computer-controlled microwave tracking system providing trackline and detection/miss range reconstruction accuracy to better than 0.1 nautical miles.

The very limited size of the detection data base did not permit a complete evaluation of the platform's performance under a wide variety of environmental conditions and in searches for a number of different target types, but it did allow for a first order estimate of small target search performance under good weather conditions. The data indicate that the airship appears to be at least as good as and possibly an even better visual search platform than fixed or rotary wing aircraft used under similar conditions. For MSA use, the airship displayed excellent versatility and adaptability, lending itself well for this type of work.

17. Key Words Airship, LTA, Search and Rescue, Marine Science Activities, Probability of Detection, Surface Target Detection	18. Distribution Statement Document is available to the U.S. public through the National Technical Information Service, Springfield, VA 22161.

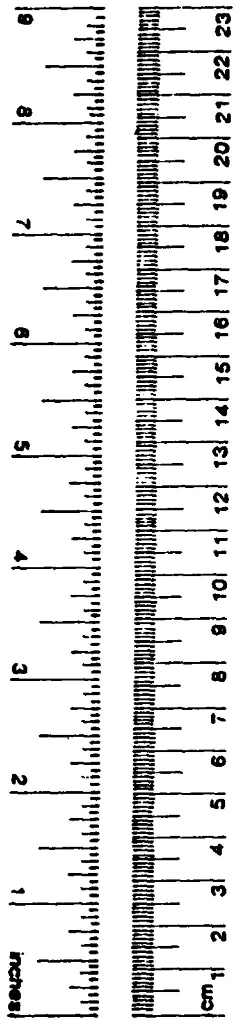
19. Security Classif. (of this report) UNCLASSIFIED	20. SECURITY CLASSIF. (of this page) UNCLASSIFIED	21. No. of Pages	22. Price

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

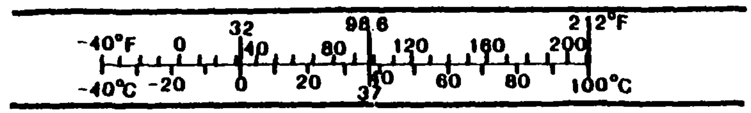
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures. Price $2.25. SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



ACKNOWLEDGEMENTS

This evaluation could not have been accomplished without the contributions of a large and diverse group of individuals. The unusual nature of the experiment and the novelty of the platform required the untiring dedication and flexibility of all those involved.

Several personnel from Coast Guard Air Station Elizabeth City, Coast Guard Aircraft Repair and Supply Center, Coast Guard Group Cape Hatteras, and Coast Guard Station Oregon Inlet contributed both their time and talents serving as observers on-board the airship and as crews for the on-scene monitor boats, assisting with modifications to the airship, and providing a variety of other services during the experiment.

The AI-500 crew and Airship Industries engineers in Weeksville during the experiment proved to be extremely cooperative and hard working.

I am especially grateful to the contributions made by Mr. Gary Hover, Dr. Donald Murphy and Mr. David Bailey who assisted in the test plan development, served as integral parts of the field research team, and completed reviews of the various drafts of this document providing invaluable suggestions and corrections. LT Joseph St. Martin, Mr. Donald Cundy, MST1 Mark Everson and MST2 James Willcox also served as members of the R&D Center field team working very long days in the set-up, operation, and tear-down of the test equipment used during this exercise.

Mr. Richard Jadamec, with the assistance of Ms. Rosemary Contin-Layne and MSTC Michael Sweetman, designed the gas sampling system, set up the equipment on the airship, and contributed to write-up of the results from this portion of the exercise.

CDR James Webster and CDR Richard MacDonald served as the Coast Guard project officers for the entire Coast Guard airship evaluation and provided on-site guidance on the integration of the R&DC experiments into the larger proof-of-concept study.

Graphic arts and photo processing work were provided by Mr. Joseph Duddie and Mr. Richard LeClercq, respectively.

A special thanks is extended to Ms. Mary Ellen Mahoney for editorial services provided and for the typing of several draft copies and the final smooth version of this document.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

1. General

During the last week in August 1983, the Coast Guard Research and Development Center completed five days of tests of an existing state-of-the-art lighter-than-air ship (LTA), the British built AI-500, which was leased for three months by the Navy, Coast Guard and NASA. These tests off Oregon Inlet, NC, were an effort to evaluate the technical characteristicsand operational capabilities of an airship of modern design and materials which offers advantages over airships of the past that include longer duration, higher payload, economical operation, and relatively high speed. Although this airship was of relatively small size (i.e., 10% smaller than the Goodyear Blimp but with 40% greater lifting power and greater versatility due to the vectored thrust of its propellers) compared to the vehicles that would be needed for Coast Guard and Navy missions, the tests in search and rescue (SAR) and as an oceanographic research platform were designed to answer some basic questions as a proof-of-concept.

During three days of the testing, targets (life rafts and persons-in-the-water) were deployed and controlled visual searches were conducted to compare the LTA performance with helicopters in similar search situations. With the limited number of types of search (low altitude (200-500 feet) and slow searches under good visibility) that were conducted the airship performed somewhat better than the helicopters. As an oceanographic platform the two days of proof-of-concept experiments included sampling surface water with a Van Dorn bottle, measurements of surface and sub-surface currents using expendable current probes and surface drift buoys (datum marker buoys), aerial photography, measuring water temperatures using expendable bathythermographs and an infrared thermal image scanner and tracer gas detection/identification using a portable gas chromatograph.

3. Conclusions and Suggestions Regarding Airships as Search and Environmental Sampling Platforms

As a platform for visual search for small objects on the surface of the ocean the AI-500 offered good visiblity, a generally comfortable environment, a relatively long on-scene endurance, low altitude and a modest range of search speeds. In searches for persons in the water, detection data collected indicate that searchers on board the LTA can obtain comparable or potentially better detection performance than conventional aircraft.

As a platform for ocean sampling it was extremely stable (no effect from waves), could interface with the ocean surface with no complications, could move rapidly from station to station, could maintain station accurately for long periods, could support the operation of a large variety of sensors both electronic and photographic during a flight (cruise), was capable of sustained operations at low altitudes (below 20 meters) without complication or consternation, and could be launched or recovered (includes exchange of gear and personnel) with no difficulties (and a crew of only 10 handlers) at its main base or at remote sites (such as the Kitty Hawk National Monument parking lot).

The shortcomings of the AI-500, only 12-14 hours endurance, weight limitations due to its small size ("prototype"), lack of creature comforts, speed limited to 55 knots, exhaust leaks into the cabin during extended hovers, and a reluctance to operate in the vicinity of potential thunderstorms, all can easily be overcome in a projected full-size airship that operates at 90 knots.

1.0 BACKGROUND

1.1 Introduction

Since the early 1970's, the Coast Guard's Office of Research and Development has been investigating a number of alternatives to the present methods of conducting major Coast Guard missions in an effort to increase both operational efficiency and effectiveness. A number of airborne platforms have been considered ranging from simple kites and parafoils to satellites and remotely-piloted unmanned aircraft. Lighter-than-air (LTA) platforms, including both unmanned tethered platforms (aerostats) and self-propelled vehicles (airships), are among the choices considered to have the most near-term promise.

In the late 1970's, the Coast Guard sponsored a Naval Air Development Center (NADC) study of the potential airships of modern design and materials have for meeting the varied responsibilities assigned to the Coast Guard. This paper study and computer simulation (Reference 1) presented some very favorable conclusions identifying a number of economic and operational advantages of airships over more conventional resources for many of the Coast Guard's missions.

Based on this study further consideration of airships was warranted, stimulating a three-month field test during the summer and early fall of 1983 sponsored jointly by the U.S. Navy, U.S. Coast Guard and National Aeronautics and Space Administration (NASA). The Coast Guard Research and Development Center (R&DC) conducted a one-week operational evaluation of the test airship in late August 1983 as part of the larger study. This report documents the conduct and analysis of only this segment of the complete field tests. A 1984 NADC report (Reference 2) will provide a complete summary of the entire three-month study.

1.1.1 History

The idea of an airship supporting a variety of missions effectively and efficiently is far from new. The year of this proof-of-concept test, 1983, marked the 200th anniversary of man's first flight using a lighter-than-air device.

Plagued by disaster, particularly in their hydrogen form (e.g. Hindenburg disaster), and challenged by the development of faster and more maneuverable heavier-than-air craft in the 1920's, 30's and 40's, rigid airships became commercially obsolete prior to World War II. For military applications, non-rigid airships (i.e. blimps) continued to be valuable through World War II. The U.S. Navy put over 150 non-rigid airships into operation during the war, using them on over 55,000 missions accounting for over 600,000 hours in the air. During this period, the airship proved very reliable and required relatively low maintenance. After the war, airships were used operationally for Anti-Submarine Warfare (ASW) surveillance (e.g. towing subsurface arrays for magnetic anomaly detection) and Airborne Early Warning (AEW) with large airborne radars installed inside their envelopes. In 1961, the last squadron of airships at Lakehearst, New Jersey, was decommissioned by the U.S. Navy due to changes in the offensive threat (i.e. missiles instead of bombers) and defense budget reductions.

Prior to 1983, the three blimps owned by the Goodyear Aerospace Corporation were the only airships operating commercially in the United States. These were and continue to be used primarily for publicity and media coverage of sporting and other public events.

Why the renewed interest in a technology that was essentially abandoned over 20 years ago?

1.1.2 New Technology

What now makes airships worthy of reconsideration is state-of-the-art designs and materials that promise to produce a stronger structure and a much more maneuverable vehicle, and the not so new considerations of long airborne endurance capability and low operating cost. The dangers associated with hydrogen were eliminated shortly after the Hindenburg disaster in 1937 with a switch to the exclusive use of inert (i.e., non-explosive) helium as the lifting gas. (The United States had switched to this more expensive gas prior to this disaster.) Manufacturers now proclaim that by using their designs to construct modern airships, the operational problems which beset airships of the past will largely be eliminated.

In addition to apparent advances in the airship's design and materials, many new sensors appear now to be ideally suited for use on a platform of this type.

1.1.3 Preconceived Expectations

Based on the theoretical data presented in the 1980 NADC report (Reference 1) and the documented performance of past airship designs, this evaluation was entered with some preconceived expectations about airships. These expectations included comfort, stability, good visibility, low vibration (insensitivity to gust), safe operation at low altitude, long on-scene time, ability to hover (i.e., stationkeeping), a wide range of operating speeds, ability to operate in low visibility, ability to interface with the ocean surface, and reasonable payload capacity. Many of these are very important for effective and efficient mission performance.

The 1980 NADC study covered the wide spectrum of potential Coast Guard maritime missions that could be performed by airships: enforcement of laws and treaties, search and rescue, marine environmental protection, port safety and security, marine science activities, ice operations, short range aids to navigation and military operations. The versatile blimp would appear to be suited to everything from responding to oil spills to serving as a convoy escort or engaging in mine-sweeping operations.

The 1980 NADC report predicted that LTAs could perform long-endurance missions beyond the capability of helicopters and some smaller vessels and interact with the ocean surface and floating units more directly than fixed-wing aircraft. Although these missions were within the capability of larger surface vessels, the airship could theoretically complete them in half the time using one sixth the fuel. The airship does not appear to threaten the existence of either surface ships or aircraft, but may complement both by relieving them of some of their operational missions that appear to be better suited to an airship. This could, in turn, free the conventional platform to focus more attention on the missions to which they are best suited (Reference 1).

With the 1980 study showing promise on paper for airships' use, proof-of-concept field tests were the next logical step in the evaluation of this technology. After completion of t' ` technical evaluation by the Navy and NASA in June and July 1983, the Coast Guard Office of Research and Development (Marine Technology Division) supervised evaluation of the operational utility of this platform. This study included lowering and recovery of a rescue boat from the airship's gondola, hoisting a person from a floating platform to the airship and a general evaluation of airships' adaptability to a variety of Coast Guard missions.

1.2 Scope/Experiment Objectives

In the five days available for the R&DC segment of field tests, experiments conducted were designed to provide a preliminary assessment of the visual search performance realized by lookouts deployed on board an airship of modern design and the potential advantage of using this type of platform for environmental measurements of interest to the Coast Guard.

The specific objectives were as follows:

1. Develop a detection data base of sufficient size to allow at least a preliminary evaluation of the airship's detection capabilities, and compare detection performance sweep widths realized from an airship to those of other Coast Guard platform(s) previously tested by the R&DC.

2. Investigate the capability to interface with the ocean surface including air and water sampling from the ocean surface and near surface, remote sensing, and air deployment/recovery of current measuring and other scientific devices.

3. Document any aspects of the airship's performance or potential observed during the test that could positively or adversely affect its performance on Coast Guard search and environmental sampling missions (e.g., ability to follow an assigned track, ease or danger in recovery at a remote site, endurance, ease of operation).

The time allocated for this entire test was five days with five to eight hours of flight time per day. Three of these days were scheduled for visual search exercises and two days for Marine Science experiments. Although this would not provide enough time to collect sufficient data to investigate all aspects of the airship's operational performance, it was expected that the limited data set would allow for a preliminary evaluation of the practicality of using this type of platform for these two applications.

2.0 AIRSHIP SPECIFICATIONS AND EQUIPMENT

In selecting an airship for this proof-of-concept test, every attempt was made to obtain a platform representing state-of-the-art design and performance. The famous Goodyear blimps (GZ-20) represent World War II-vintage technology and thus did not provide many of the features offered by modern design and materials. A British company, Airships Industries, Inc., was the only company found to have produced an airship that incorporated many of the novel design features desired for these tests (see Figure 2.1). Although their model AI-500, first produced in 1981, fell short of many of the specifications defined as optimal in the 1980 NADC report (Reference 1), this airship could be used to provide answers to some of the basic questions concerning modern airships' versatility, capability, characteristics and operating costs as they would be used to perform Coast Guard missions and thus allowed many of the test objectives to be addressed.

The third airship in the AI-500 model series was leased jointly by the Coast Guard, Navy and NASA for the three-month field test from mid-June to mid-September 1984. This airship was fabricated in Great Britain, shipped to Canada and assembled in Toronto during early 1983 at the facilities of LTA, Inc., a newly formed subsidiary of Airship Industries. It completed its maiden flight in April 1983. The lease of this airship included pilots, ground crew, a ground support truck, and maintenance/repair.

Figure 2-1. AI-500 Airship

The AI-500 model offers the following state-of-the-art features:

-A vectored thrust capability, achieved by twin, gasoline-powered, swivel-mounted fans that allow the airship to take off heavy (i.e., with negative buoyancy), thus increasing payload and improving maneuverability markedly. This feature also reduces the number of ground crew required to handle the airship.

-Ducted fans which reduce propeller noise levels both in the gondola and on the ground, provide improved safety to ground personnel and increase the efficiency of the propeller.

-Use of advanced high strength, lightweight materials (Kevlar for suspension cables, a rigid structure of glass reinforced plastic, dacron/polyurethane/saran for the envelope, honeycomb sandwich composites) that provide:

a. All plastic main structures (long life and low maintenance costs)

b. Low permeability envelope material (reduces the leak rate).

Although the AI-500 is 10% smaller than the Goodyear blimps, it theoretically has about 40% greater lifting capacity due to the ability to use dynamic lift during vertical takeoff (typically taking off at 15% negative buoyancy) and the use of these modern lightweight materials.

Table 2-1 provides a comparison between the specifications of the AI-500 and the Marine Patrol Airship (MPA) recommended in Chapter V of the NADC paper study (Reference 1) as the optimal platform for general Coast Guard use.

TABLE 2-1
AI-500 and MPA Specifications

	AI-500	MPA
Length	50 m	99 m
Diameter	14 m	22 m
Envelope Volume	5,100 cu. m	24,800 cu. m
Lift from Helium	4,600 kg	23,700 kg
Max Gross Weight	5,250 kg	27,600 kg
Useful load	2,000 kg 2 pilots + 400 kg fuel + 1425 kg 14 cu. m	10,200 kg
Maximum Altitude	2,900 m	3,000 m
Horsepower	408 hp	2,400 hp
Maximum Speed	55 kts	97 kts
Cruise Speed	45 kts	60 kts
Fuel Consumption (@ Cruise Speed)	36 kg/hr	136 kg/hr
Endurance	12-15 hrs	20-50 hrs
Range	700-1100 km	
Empty Weight	3,385 kg	
Power	Twin, air-cooled Porsche 930 engines 6 cylinder, 3 liter, air cooled	
Propeller	1.4 m diameter (5) variable-pitch blades in ducted fans	
Tail Span	17.0 m	
Gondola	9.2 m long	
Cabin	4.2 m long 2.4 m wide (max) 1.9 m high	
Navigation	Normal IFR Avionics, Omega, Automatic Direction Finder (ADF)	

The AI-500 came outfitted with a MEL MAREC II Radar with a 107 cm by 42 cm antenna mounted inside the airship envelope. Also provided by the manufacturer was a MARCONI Thermal Imaging System (TICM II) mounted on a tripod in the cabin and designed to be hand-aimed at points of interest on the ocean surface.

A specially designed mobile mast/ground support truck was provided by Airship Industries that had a mast for mooring the airship, served as a mule to move the airship around while on the ground, had fuel storage to permit refueling of the airship, and could be equipped with communications equipment to maintain contact with the airship while in flight (see Figure 2-2).

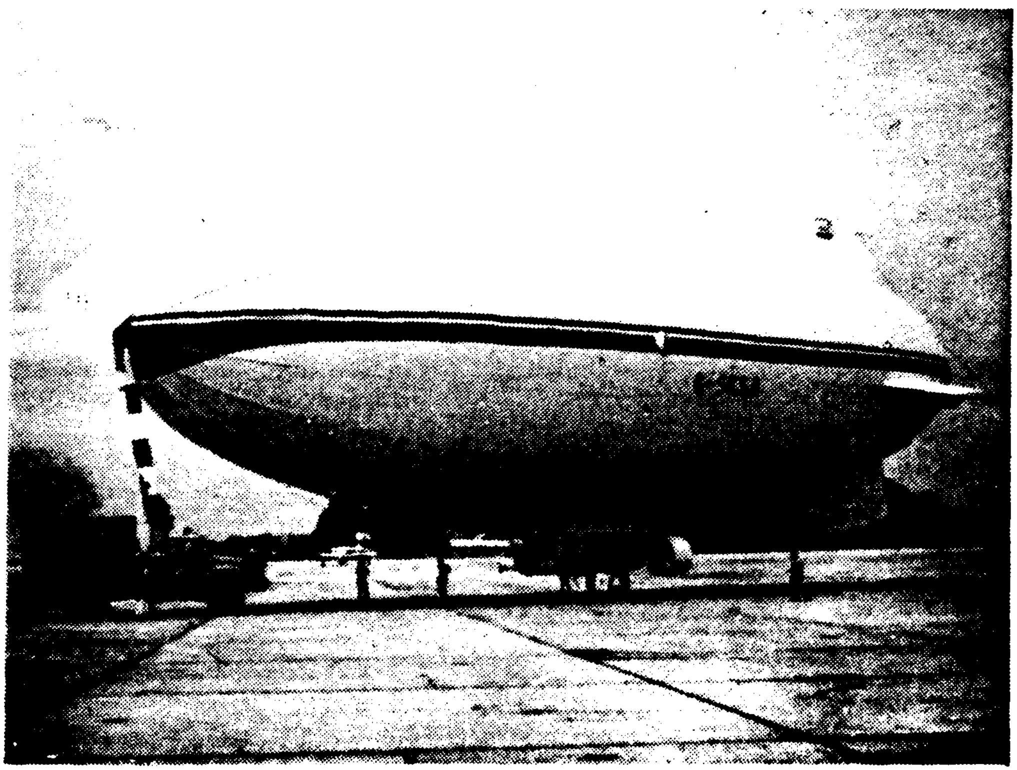


Figure 2-2. AI-500 Mobile Mast and Ground Support Truck

The interior of the airship's gondola can be configured in a variety of ways. The line drawing in Figure 2-3 shows the arrangement of the gondola for this test.

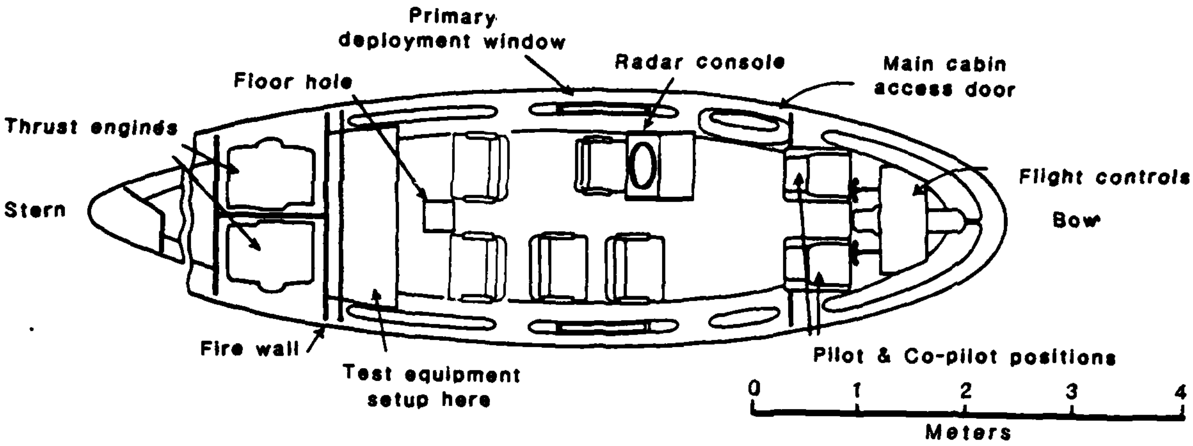


Figure 2-3. AI-500 Gondola as Arranged for the Coast Guard Field Tests

Some of the state-of-the-art design features that were not incorporated in the AI-500 were in the areas of:

Ground handling equipment
Power-assisted controls and auto pilot
Navigation interfaces
Advanced hover ability (bow and stern thrusters)

3.0 EXPERIMENT DESCRIPTION

3.1 Introduction

3.1.1 Exercise Period and Operating Area

The technical evaluation portion of the Patrol Airship Concept Evaluation (PACE) was completed at the Naval Air Test Center in Patuxent River, Maryland, during the first 7 weeks of the field test. This was followed by the operational evaluation tests including the portion documented in this report. During this part of the evaluation, the airship was based at Weeksville, NC. This site was selected because of the existence and availability of a large airship hangar built by the U.S. Navy during World War II, the proximity of the Coast Guard Air Station and Aircraft Repair and Supply Center (AR&SC) in Elizabeth City (less than 3 miles away) (see Figure 3-1), and the nearby availability of open ocean areas over which the airship could be tested.

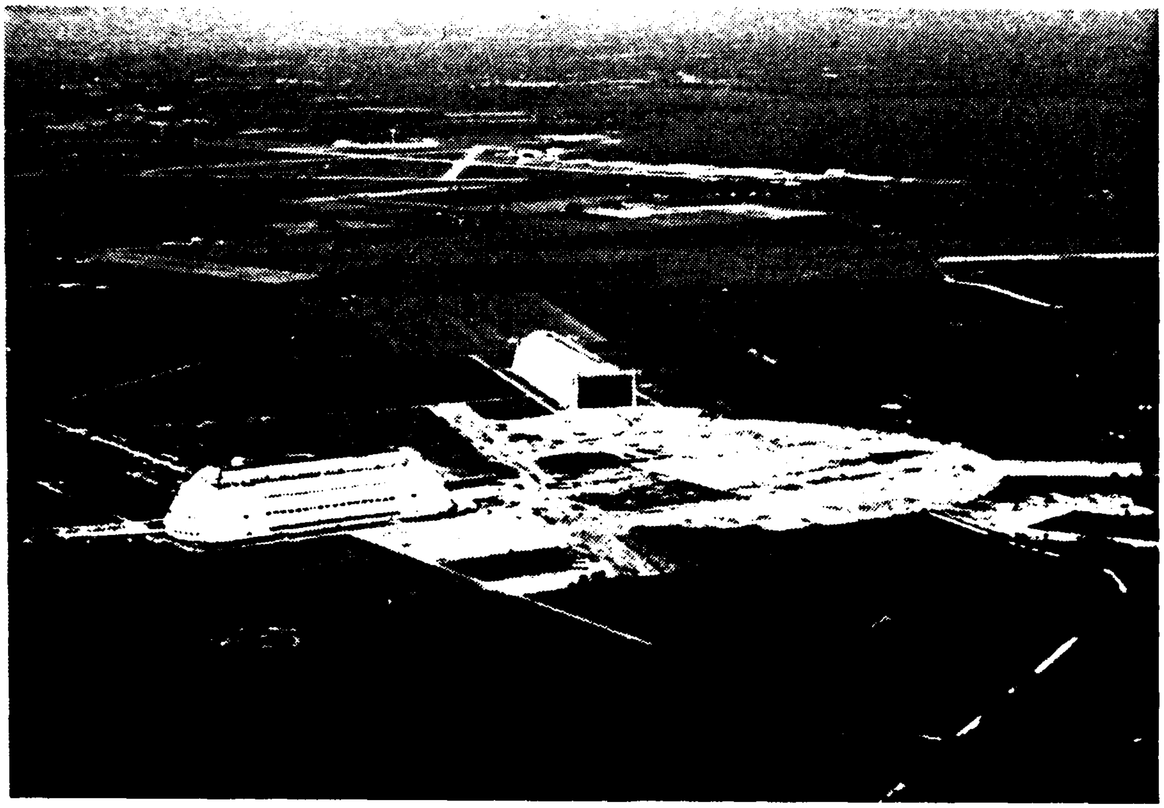


Figure 3-1. Aerial Photograph of Weeksville Hangar with AR&SC and CGAS Elizabeth City in the Background. The Airship is Shown on Landing Pad to Right.

Visual search and environmental sampling experiments were conducted during the week of 22 August 1983 over the Atlantic Ocean off Oregon Inlet, NC, within a 15 by 30 nautical mile area centered at 35-50.3N, 75-22.1W. Actual search areas and search patterns (shown in Appendix A) assigned to the airship each day depended upon data collection objectives and weather conditions expected. The search areas were typically 8 nautical miles by 6 nautical miles. Figure 3-4 shows the position of the reference stations used by the microwave tracking system (MTS) described in section 3.2.3.

3.1.2 Participants

The experiment was coordinated and data collected by a field team from the Coast Guard Research and Development Center in Groton, Connecticut. Members of this team manned the tracking system and operations center established for this exercise at Coast Guard Station Oregon Inlet, North Carolina. The R&D Center Field Team also provided coordinators on the on-scene monitor boats and served as observers and data recorders on the airship. Tracking and primary shore-based communications equipment, search targets and most of the logistic support for the Field Team were provided by the R&D Center.

All support for and operation of the airship - including pilots and ground crew - were provided by Airship Industries under the lease agreement. During the evaluation, the airship was flown by British licensed commercial pilots employed by Airship Industries. The ground crew consisted of a project manager who supervised all aspects of the airship support, engineers who directed necessary modifications to the airship required for this experiment, and line handlers supervised by a crew chief. In addition to assisting during takeoffs and recoveries of the airship, the line handlers also performed general maintenance, provided 24-hour helium pressure watches, and assisted with modifications to the airship.

Lookouts and additional ground crew were provided by Coast Guard Air Station Elizabeth City and the AR&SC. These individuals were Coast Guard pilots and crewmembers with many years' experience in Search and Rescue missions who provided a great deal of insight into the utility of this platform compared to aircraft presently used by the Coast Guard. Their comments are included in Appendix B. These were the same type (i.e. training/experience level) of people used in previous detection experiments conducted by the R&DC adding to the validity of comparisons that will be made between detection performance from airships and conventional platforms.

The operations center (R&D Control) for this exercise was located in a small out-building at the base of Station Oregon Inlet's primary communications tower. The microwave tracking system and landline and VHF-FM communications equipment were located in this building manned by two field team members. Station Oregon Inlet also provided the services of its 30-foot and 44-foot utility boats (UTBs) when needed for target deployment and retrieval.

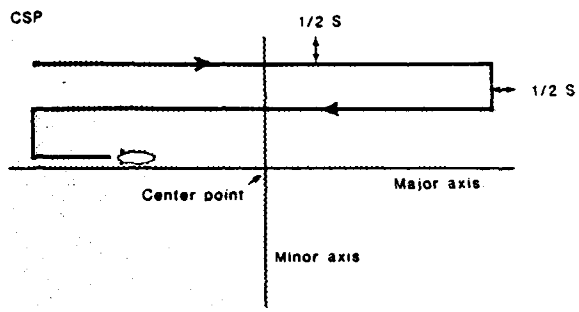
The commercial fishing vessel OUTLAW, Coast Guard Cutter POINT BROWN, and utility boats from Station Oregon Inlet were employed on different days as the on-scene monitor boat for the exercise.

3.2 Experiment Design and Conduct

A detailed outline of this experiment's design and rationale for conduct is provided in a Test Plan distributed prior to the start of the field exercises (Reference 3).

3.2.1 Visual Search Detection Performance

Visual searches were assigned as they would be for a Coast Guard aircraft on an actual SAR mission. Parallel search (PS) patterns (see Figure 3-2) were assigned as prescribed in Chapter 8 of the National Search and Rescue Manual (Reference 4). A copy of a typical exercise message assigning a day's operating area is provided in Figure 3-3. Targets were



Note: Search legs were parallel to the direction of the major axis of the search area and were seperated by a specified track spacing. Commence search points (CSP) and outer search legs were one-half the track spacing (S) inside the perimeter of the search area.

Figure 3-2. Parallel Search Pattern

```
PR
FM    COGARD STA OREGON INLET NC
TO    COGARD AIRSTA ELIZABETH CITY NC
INFO  COGARD R AND DC GROTON CT
      COMDT COGARD WASHINGTON DC
      CCGDFIVE PORTSMOUTH VA
      COMCOGARDGRU CAPE HATTERAS NC
      USCGC POINT BROWN
BT
UNCLAS //N03900//
PASS TO WEEKSVILLE AIRSHIP CREW VIA AIRSTA OBSERVERS
SUBJ:  AIRSHIP SAREX 03-83 27 AUG 83
1.  SITUATION:
    A.  VISUAL SEARCH EXERCISE FROM AI500 AIRSHIP OFF OREGON INLET NC
    B.  TARGETS:  ORANGE LIFE-JACKETED PERSONS-IN-THE-WATER (PIW) AND ORANGE
CANOPY LIFE RAFTS
    C.  FORECASTED WX FOR 27 AUG:  WINDS NW/10 KTS, SEAS 1 TO 3 FT, VIS 10NM
    D.  MONITOR BOAT:  STA OREGON INLET'S UTB, ON SCENE AS OPS PERMIT
2.  SEARCH AREA
       AREA              SIZE        MAJOR AXIS         CENTER POINT
ALFA/BRAVO/CHARLIE     8 X 6 NM       170 M          35-52.4N 75-26.6W
3.  EXECUTION
    SEARCH       PATTERN       CREEP      ALT      SPD        START POINT
    ALFA           PS           080       500      35      35-54.9N 75-30.9W
    BRAVO          PS           260       500      35      35-56.5N 75-25.0W
    CHARLIE        PS           080       200      35      35-54.9N 75-30.9W
4.  COORDINATING INSTRUCTIONS:
    A.  1.0 NM TRACK SPACING
    B.  AI500 ON SCENE TIME 270900 LOCAL
FROM R AND DC FIELD TEAM
BT
```

Figure 3-3. Example of Visual Search Exercise Message placed randomly within the search area and moved periodically by the monitor boat to prevent biasing the data due to crew alertment to target positions. Every effort was made during these searches to maintain realistic crew motivation levels and utilize standard SAR mission procedures. The only exception to this policy was that, when a possible target was reported by the aircrew, no deviation from the intended search track was made to investigate the sighting. All target sightings were recorded by an onboard R&D Center observer and verified during post-experiment analysis of data logs and searcher/target position plots generated by the MTS. On-scene environmental conditions were recorded by the on-board observer and by personnel on the on-scene monitor boat.

3.2.1.1 Search Targets

Visual searches were conducted for anchored 4- and 6-man orange-canopied life rafts and simulated persons-in-the-water (PIWs) with orange life jackets. The PIWs were the primary search targets and the exercise was designed to provide the maximum number of detection opportunities for this target type. Life rafts were used to maintain the interest of the lookouts and to provide a check on their performance. The PIWs were fiberglass mannequins which were modified to ride in the water in a position and at a height above the surface that would be expected of life-jacketed humans of average stature. Life rafts were weighted to approximate the ride and freeboard of a raft with the designed number of survivors. The number of targets set in a search area varied from day to day and even over the course of a single day, typically ranging from four to six. All targets were normally recovered at the end of each day and then redeployed on the morning of the next experiment day. This procedure not only prevented the loss of targets overnight but also provided a confirmation of all target positions at the end of the day. When significant drift of a target occurred, detection data related to that target which occurred after the last reliable position fix were not considered in the analysis.

The total number of visual detection opportunities that occurred for each target type is summarized in Chapter 4 (see Table 4-1).

Due to the limited size of the detection data base that could be expected to be collected during the three days available for visual detection experiments, every effort was made to eliminate variations in parameters (e.g. search target type, altitude, search speed, etc.) potentially affecting search performance. This hopefully would permit the identification of the effect of differences in search unit type (i.e. airships versus other platforms).

LTA vehicles similar to the AI-500 are likely to represent significant improvements in mission effectiveness over existing platforms only in scenarios where their unique combination of favorable crew environment, moderate-speed transit, high on-scene endurance, low speed/altitude operation, hover/deploy/recover, and moderate-to-high payload capabilities can be taken advantage of. Few missions demand this combination of platform capabilities more than a search for, and recovery of, persons in the water (PIW).

Simply stated, LTA vehicles appear to have most of the desirable features of both surface and air craft while suffering few of their limitations. The PIW SAR scenario is one that demands the combined "plus" features of both surface and air platforms to a greater extent than most other missions. PIWs were thus selected as the primary search targets because they provide the most challenge and offer most room for improvement over the existing detection performance possible from conventional Coast Guard resources.

3.2.1.2 Tracking and Reconstruction

Target locations and search unit positions were monitored using an automated tracking system consisting of a Motorola MiniRanger III mobile tracking system coupled with a Hewlett-Packard 9845B mini-computer. This system was developed by the Coast Guard R&D Center for the Probability of Detection in Search and Rescue (POD in SAR) Project to present and record target and search unit positions allowing track reconstruction accurate to better than 0.1 nautical mile. Its operation is described in detail in a 1981 R&DC report (Reference 2).

The MTS master station was located on the microwave tower at Coast Guard Station Oregon Inlet, NC. Two secondary stations were located on a microwave tower in Waves 23 kilometers to the south and Nags Head municipal water tank 19 kilometers to the north. These locations, which facilitated line-of-sight tracking of searcher and target positions, are depicted in Figure 3-4.

Target positions were marked by the on-scene monitor vessel(s) equipped with MTS transponders when the targets were first anchored, and again when they were picked up. Positions of the transponder-equipped airship were monitored continuously by the MTS when within the exercise area

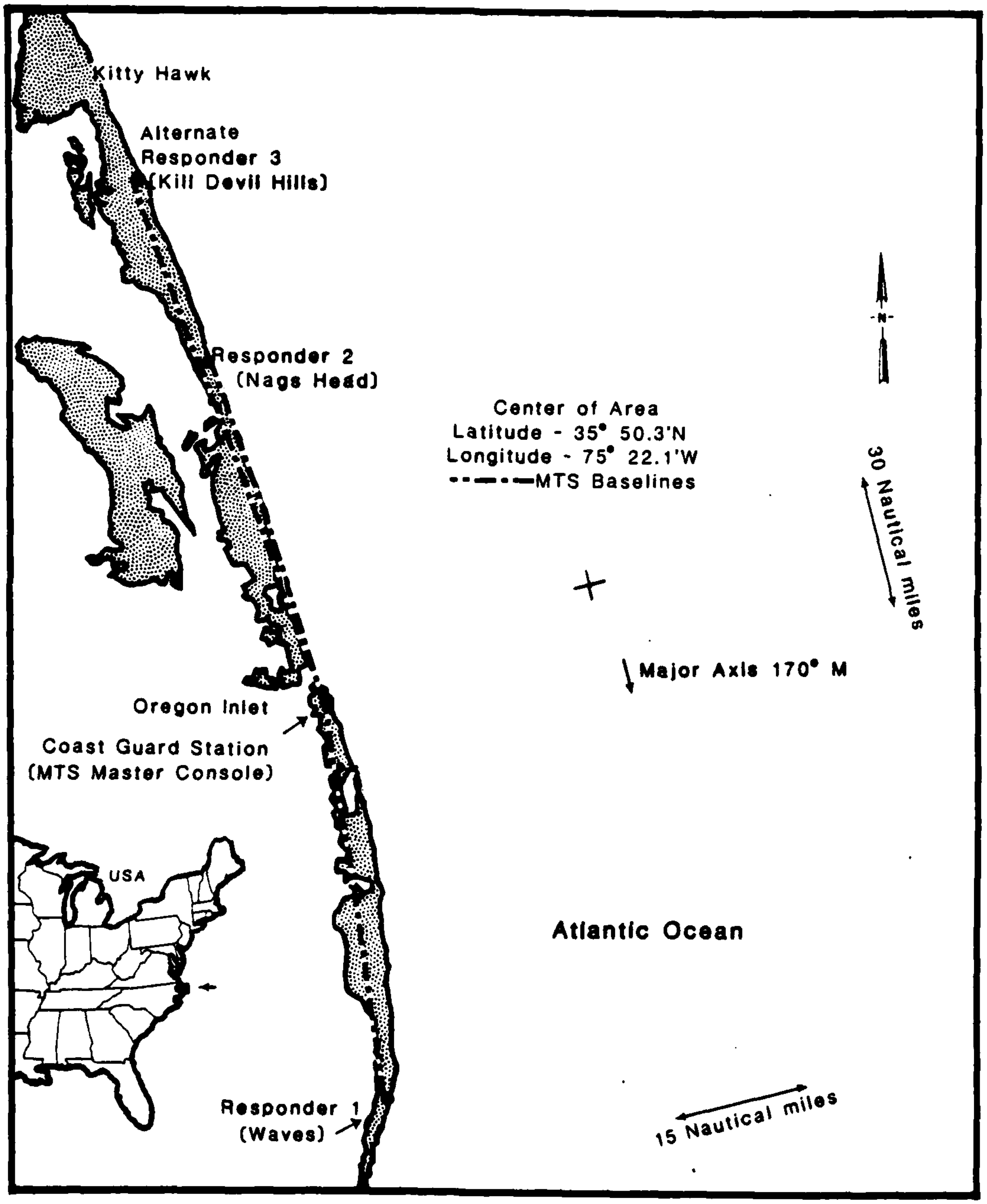


Figure 3-4. Exercise Area off Outer Banks of North Carolina

and recorded on magnetic tape every 10 to 30 seconds. Outputs of the MTS included a real-time CRT display of the search area, target positions, and airship tracks; a hard copy of airship, target and monitor vessel positions; and a 30 cm by 43 cm (11" by 17") position/time plot of each search. An example of the real-time MTS display is shown in Figure 3-5. All search tracks completed during this test are presented in Appendix A.

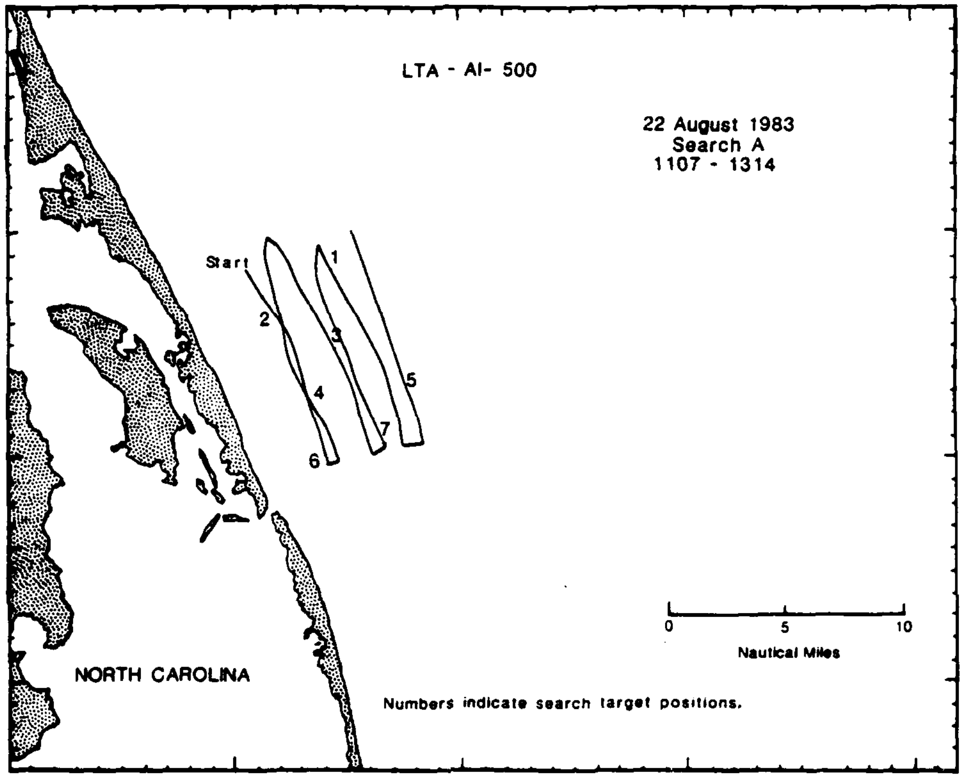


Figure 3-5. Example of Microwave Tracking System (MTS) Real-Time Display

Valid sightings of SAR targets were determined by comparing sighting reports (maintained by observers on board the airship) to the reconstructed search plots. For each sighting recorded, the time of the sighting and estimated target range and relative bearing were compared to actual target positions. If a sighting was determined to be a valid detection, the lateral range and value of other explanatory variables were recorded. The airship's maximum lateral range of detection for liferafts and for PIWs on a day in question was determined. This value was multiplied by 1.5 and became the criteria for determining the number of targets of opportunity (maximum lateral ranges for the airship on the day tested). A multiplier of 1.5 was selected to provide sufficient data to identify the maximum detection range (MDR) without adding a large number of meaningless (long-range) misses. Any target whose lateral range was less than or equal to 1.5 times the maximum lateral range of valid detections and was not recorded as a sighting was determined to be a "miss." The lateral range and other explanatory variables for all targets of opportunity (detection or miss) were recorded in the same manner. Thus a separate raw data file was developed for each search day that included all valid target sightings and all misses that met the criterion above.

3.2.2 Environmental Sampling Experiments

The intention of the environmental sampling (i.e. marine science) experiments was to demonstrate the ability to make a variety of environmental measurements and observations and to collect samples from an airship. These proof-of-concept experiments were not designed to collect any meaningful sensor or sampling data useful in understanding the environmental conditions (e.g. surface current, vertical temperature profiles, air quality, etc.) that existed in the exercise area during the experiment.

3.2.2.1 Environmental Sampling Equipment

The equipment used during the environmental sampling experiments was chosen to be representative of those devices and sensors that would prove most useful in the conduct of Coast Guard missions. Measurements and samples included the following:

a. Current measurement

- Expendable Surface Current Probe (ESCP) consisting of a plastic tube holding three floats (each of which contains a bright green fluorescent dye packet) and a timing mechanism. The tube with a small parachute attached is normally deployed from an aircraft. When it reaches the ocean surface, the parachute detaches and one of the three floats breaks free, releasing its dye. The tube sinks at a known rate through the water column to the ocean floor where the two remaining floats are released at pre-set times. For this experiment, the first float is released approximately 76 seconds after being dropped from the airship and the second 72 seconds after the first. After release, the floats rise to the surface at a known rate. Upon reaching the surface, they capsize and release their dye. Knowing the time difference between the release of the floats and photographically measuring the separation of the dye marks at the surface using the altitude and lens type, a surface current can be calculated. A full description of this operation is contained in Reference 5.

- Datum Marker Buoy (DMB) consisting of a small float with a parachute attached designed to be deployed from an aircraft. It contains a small transmitter that transmits a continuous RF signal allowing an aircraft outfitted with a directional receiver to relocate the buoy several times during one or more sorties. Having very little surface area above water on which the wind can act, the float will drift with the surface current. By redetermining the float's position, observers on the aircraft can calculate the speed and direction of the local (on-scene) current.

- Drift cards fabricated from .6 cm (1/4") thick sheets of exterior grade plywood. These were cut to a size of 1.2 meter square (4 ft x 4 ft). Each sheet was painted fluorescent orange and black with individually recognizable patterns to allow easy differentiation when floating on the ocean surface. Both sides of each card were painted with the card's identifying symbol. This eliminated any concern over which side of the card ended facing up when reaching the ocean surface.

Knowledge of ocean currents (primarily surface) patterns is vital to the efficient and effective conduct of many of the Coast Guard's primary missions. These include uses in Search and Rescue (search planning), International Ice Patrol (iceberg movement) and Marine Environmental Protection (oil/hazardous chemical point of origin or predicted landfall).

b. Ocean Temperatures

- Sippican MK-9 Digital Expendable Bathythermograph (XBT) System including T-4 probes, a model LM 3A hand-held launcher, MK-9 front-end processor, and an HP-85F micro-computer. This system measures and graphically displays ocean temperature versus depth. The sensors are housed in expendable probes that are dropped from a launcher and sink through the water column at a known rate while transmitting temperature data back to a front-end processor over a fine wire link. This wire breaks free after paying out to its full length, terminating the link. The T-4 probe was selected for use in these tests. It records to a maximum depth of 460 m within a temperature range of -2.2°C to 35.6°C. The same system can be used to deploy other XBT probes, sound velocity probes (XSV) and, with modification, conductivity (salinity)/temperature/depth probes (XCTD).

- Marconi Thermal Imager - This is an infrared sensing camera providing a black and white display on a Cathode Ray Tube and recorded on a video recorder. The presentation provided a relative gradation of surface temperatures with varying shades of grey between white and black. Absolute temperatures were not readily determinable.

Temperature data are helpful in detecting ocean current patterns for applications discussed in previous paragraphs, identifying water temperatures, and calculating the speed of sound through water, to name a few uses.

c. Aerial photography

- 70 mm Hasselblad cameras with 50 and 100 mm lenses, and a 35 mm Pentax camera with a 50 mm lens. These were mounted over a 60 cm by 30 cm hole cut in the floor of the gondola providing an unobstructed vertical down-look. Kodak Aerocolor Negative (Film #2445) and Kodak Plus X Aerographic (Film #2402) were used with the Hasselblad. Ektachrome 64 was used with the Pentax. The Aerocolor is a high speed, color negative film and the Plus X is a medium speed black and white film with high dimensional stability. Both film types are typically used for aerial mapping and reconnaissance.

Aerial photographs have a number of invaluable uses in survey work, documentation, and image analysis. For Coast Guard missions, applications include recording drift observations (e.g. dye diffusion, drift card dispersion), case documentation, and measuring iceberg deterioration. Airships appear to provide an ideal platform for this type of photography.

d. Water sampling

- A General Oceanics 1.7 liter GO-FLO sample bottle attached to a 6.35 mm (1/4") by 50 meter piece of polypropylene line. A 410 gram messenger (i.e., weight attached to the line) was used to actuate the closure device on the bottle after it was lowered into the water. This system can be used for surface and subsurface ocean water sampling useful in marine environmental protection, law enforcement and fisheries management missions.

e. Gas sampling

- AID (Analytical Instrument Development, Inc.) Model 511 Portable Gas Chromatograph, a Hewlett-Packard 3390A Reporting Integrator, Gillian Instrument Corp. Model 246 Vari Hi-Flow Sampler Pump, Millipore Corp. Vacuum-Pressure Pump, and 15 meter (50 ft), 30 meter (100 ft) and 45 meter (150 ft) lengths of 1 cm (3/8") inner diameter Teflon tubing. The lengths of tubing were lashed together forming an integrated tube 45 meters long with three outlets at one end. With the airship at an altitude of 45 meters and 42 meters of the integrated tubing extending below it, air samples could be taken at 3 meters, 18 meters, and 33 meters above the ocean surface without having to take in or pay out tubing or change the airship altitude.

This type of sampling could be useful in the detection and monitoring of chemical vapors released from damaged tankers and/or vessels transporting contraband materials.

3.3 Analysis Approach

3.3.1 Search Data Analysis

3.3.1.1 Measure of Search Performance

Visual search performance was evaluated by computing probability of detection versus lateral range achieved by the airship for the various combinations of significant search parameters (e.g., target type, search altitude, environmetal condition). Lateral range is defined as the closest point of approach for a detection opportunity (see Figure 3-6). Curves fitted to the airship data points were compared to curves based on the performance of other Coast Guard aircraft during earlier R&D Center experiments (for which similar conditions existed) to quantify any difference in search performance.

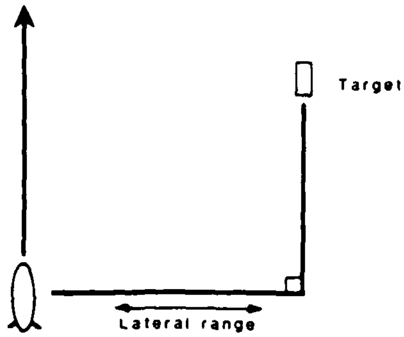


Figure 3-6. Depiction of Lateral Range

From literature searches, 25 parameters have been identified as having a potential influence on visual detection. These parameters can be divided into three categories:

1. Primary, independent measurable parameters,
2. Interdependent human factors, and
3. Secondary parameters.

Primary variables are those that have been investigated during the series of Probability of Detection in Search and Rescue (POD/SAR) visual detection experiments. They are:

1. Search and Rescue unit (SRU) type,
2. Target type (size, shape, and color),
3. Meteorological visibility*
4. Altitude
5. Search speed,
6. Time on task,
7. Sun's elevation,
8. Wind speed,
9. Significant wave height (Hs)**, and
10. Cloud cover

* Meteorological visibility is defined as the maximum range at which a large object can be distinguished. This parameter has been used in POD/SAR Project experiments to be consistent with the National SAR Manual and to avoid using subjective measurement, such as effective visibility. When used in this report, "visibility" refers to "meteorological visibility."

**Significant wave height is approximately the height an experienced observer will give when estimating the height of waves at sea.

These same variables were recorded during this experiment. Due to the limited size of the data set and limited range of environmental conditions encountered, the effect of most of these parameters could not be determined with any statistical validity. A first order estimate of the effect of variable #1 (search unit type) was possible.

3.3.1.2 Analysis of Visual Search Data and Comparison to Other Aircraft

The primary question to be addressed in the airship detection analysis was how this search platform compared to other platforms used for visual search. After preliminary sorting and plotting of the raw search data, the data were input to a sophisticated binary, multivariate regression analysis technique (LOGODDS) which is discussed in detail in a 1981 report (Reference 3). While the LOGODDS technique is usually applied to fairly large data sets to evaluate the effects of many variables, it was used more as a convenient means of fitting lateral range curves to the relatively small data set available in this case. This analysis provided a smooth lateral range curve fit to the plots of raw detection/opportunity ratio allowing comparison to data sets and lateral range curves from other search platforms which had been analyzed similarly during previous R&D Center work.

3.3.2 Environmental Sampling Data Analysis

Analysis of the Environmental Sampling data was carried to the point of reducing the data to the level where it could have been useful in a real survey of the operating area. This was done to insure that measurements made were accurate and complete. As stated earlier, the objective of this portion of the evaluation was to determine whether a variety of experiments could be conducted from the airship. For this reason, results are given primarily in qualitative not quantitative terms.

4.0 RESULTS

4.1 Introduction

A total of nearly 110 man-hours of flight time aboard the AI-500 airship was accumulated by Coast Guard observers during the 6 flights monitored by the R&DC Field Team. Table 4-1 provides basic facts concerning these flights.

Table 4-1. Summary of R&DC Airship Flights

Day	Mission	Search Alt (m)	Search Spd (kt)	Number of Sorties	Flight Hours	Detections/ Opportunities Rafts	Detections/ Opportunities PIWs
28 Jun	Demo	VAR	VAR	1	.5	-	-
22 Aug	SAR	200 & 500	35	1	7.25	9/17	9/14
24 Aug	Sampling	VAR	VAR	1	5.5	-	-
25 Aug	SAR	500	35	1	5.5	3/6	1/6
26 Aug	Sampling	VAR	VAR	1	7.25	-	-
27 Aug	SAR	500	35	1	6.25	-	12/28
			TOTAL	6	32.25	12/23	22/48

Environmental conditions ranged from fair to excellent on the days that visual search exercises were conducted. Table 4-2 summarizes the range of conditions encountered during the airship evaluation.

Table 4-2. Environmental Conditions Summary

	22 Aug	24 Aug	25 Aug	26 Aug	27 Aug
Winds (direction from) (speed in knots)	SE/5	NE/10-15	NE/20-25	NE/15	SE/5
Waves	.5 ft	2 ft	6-8 ft	2-4 ft	.5 ft
White Caps	None	Some	Many	Some	None
Visibility	15+ nm	6 nm (haze)	8 nm	15+ nm	15+ nm
Cloud Cover	3/10	9/10	9/10	3/10	2/10

Original experiment objectives included an evaluation of the ability of the airship to follow an assigned track. Unfortunately, the navigational equipment on board did not allow the pilot to determine his absolute position with any useable degree of accuracy. (Although an Omega system was installed on the AI-500, it did not provide sufficient accuracy to be useful during these experiments.) R&D Control had to guide the airship into the start search point and advise when search legs and cross legs were completed. The ability of the pilot to maintain a course on individual search legs indicated that if outfitted with the proper navigational equipment (e.g. integrated Inertial Navigation System (INS), LORAN-C and Distance Measuring Equipment (DME)), this airship would have been able to maintain at least an acceptable trace of the assigned tracks for a PIW search (i.e., 1 nm track spacing).

4.2 Visual Search Performance

The primary objective to be addressed in this analysis was the comparison of this platform to other airborne platforms previously tested by the R&DC team.

4.2.1 Visual Detection of PIWs

During the three days available for search exercises, a total of 48 PIW detection opportunities were provided for the airship lookouts. Lateral range curves were developed, as discussed in section 3.4.1, using these data. The data were separated into two sets differentiated by the environmental conditions encountered during the searches. The larger set, comprised of 42 of the 48 detection opportunities, represented excellent weather conditions defined as winds between 5 and 10 knots, visibility greater than 5 nautical miles, and significant wave height less than 2 feet. The second set, all collected on 25 August, was comprised of data collected when the winds exceeded 20 knots and the waves had built to greater than 5 feet. The 6 detection opportunities provided under these poorer conditions did not represent sufficient data on which to perform a meaningful statistical analysis.

To evaluate LTA visual detection performance, the closest-points-of-approach (i.e., lateral ranges) for the 42 target detection opportunities were sorted into .1 nautical mile bins. The detection/opportunity ratio for each bin was then plotted to produce a "raw data" lateral range curve. A computer-generated, statistical fit (i.e. LOGODDS) to these data points was used to generate a smooth lateral range curve for PIW visual search from an airship in excellent conditions. Figure 4-1 provides a comparison between this curve and one produced from PIW visual searches from helicopters (i.e. HH-52A) conducted under similar, but not identical, conditions. The helicopter data were collected during R&DC Search and Rescue exercises completed between 1978 and 1981.

Although the superior performance of the airship indicated by these curves may be due to unique characteristics of the airship (e.g. large single-pane windows, stable and comfortable ride, ability to carry more lookouts), the conditions under which the data were collected may account for part or all of the calculated difference. These factors include:

a. Helicopter data were collected in 1 to 2 foot waves while the waves encountered during the airship tests were closer to 0.5 foot. This could be a significant factor accounting for some of the observed difference between the airship and the helicopter.

b. The airship flew at 35 knots versus speeds between 60 and 90 knots for the helicopter, thus provided a longer look time.

c. Factors believed to be of less significance included differences in search altitude (a larger percentage of searches at 500 feet for the airship and 200 feet for the helicopter) and cloud cover (averaging .23 for the airship and .4 for the helicopter).

d. The relatively small size of the airship data base produced some relatively large confidence bounds.

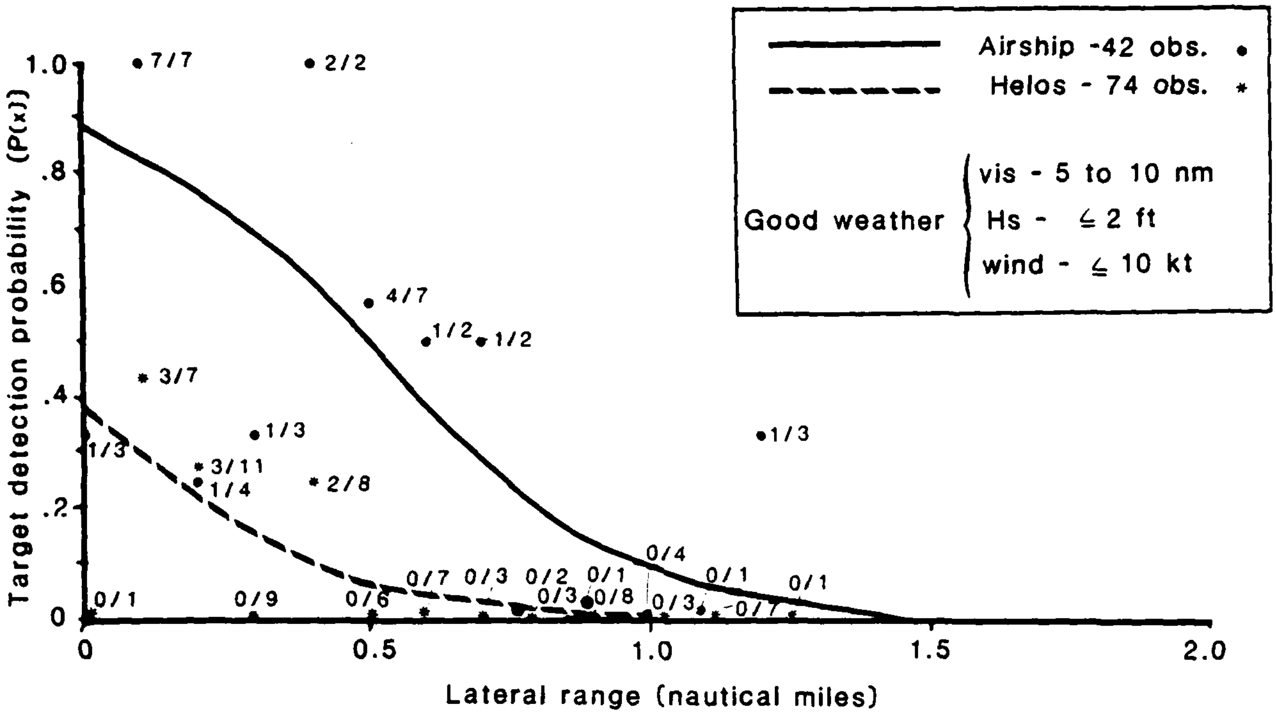


Figure 4-1. Comparison of Lateral Range Curves for a Helicopter and Airship in Visual Searches for PIWs Under Excellent Search Conditions.

Figure 4-2 provides a comparison between the airship lateral range curve and one developed from fixed-wing aircraft visual search data. The fixed-wing data set used for these curves were collected under conditions nearly identical to those experienced during collection of the data used to develop the airship lateral range curve. The only significant difference in the parameters associated with the two data bases was the search speed (i.e. 160 to 200 knots for the fixed-wing and 35 knots for the airship). See section 3.4 in Reference (3) for a complete discussion of fixed-wing aircraft detection of PIWs.

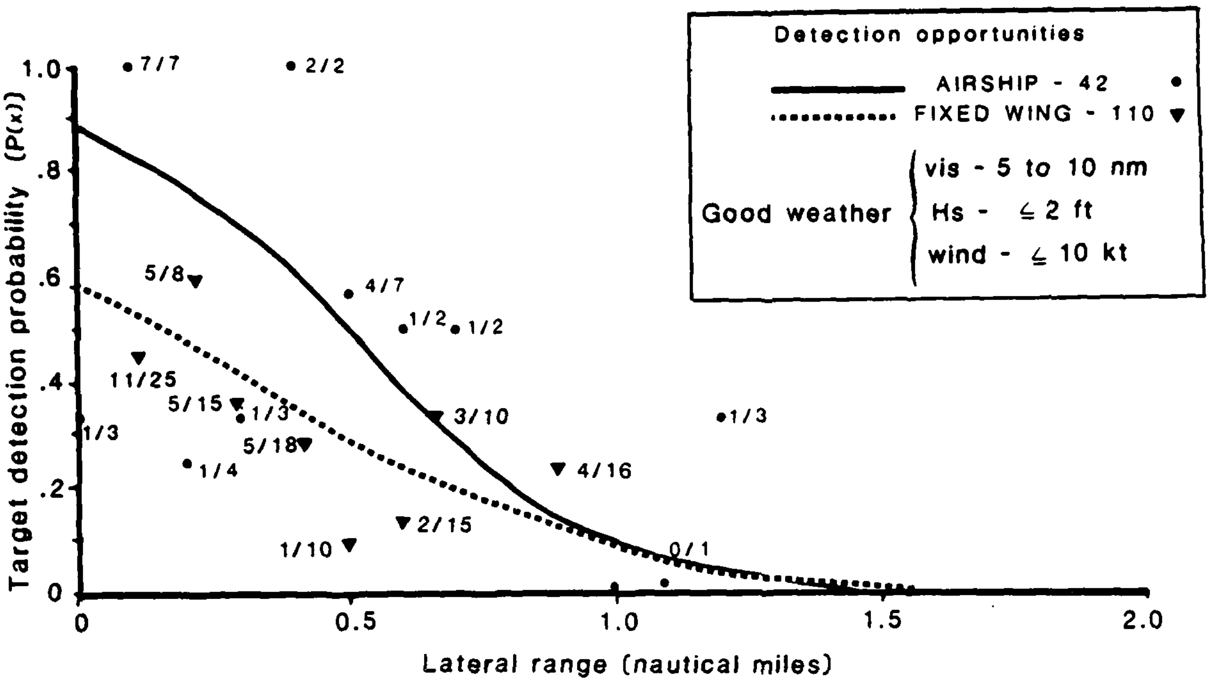


Figure 4-2. Comparision of Lateral Range Curves for Fixed-wing Aircraft and an Airship in Visual Searches for PIWs Under Excellent Search Conditions.

4.2.2 Visual Detection of Life Rafts

A total of 23 detection opportunities for life rafts were provided during the search experiments. Nine of these opportunities occurred on 25 March and the remainder on 23 March. Unfortunately, these two days provided significantly different environmental conditions, thus requiring them to be treated as two separate data sets. The extremely small size of the two data sets did not permit the development of any statistically sound conclusions concerning the visual detection performance from an airship in searches for small life rafts.

Figure 4-3 provides a graphic representation of the life raft lateral range data obtained from the airship. The data indicate that no difference in detection performance was demonstrated between the two search dates, even with different weather. This is in no way worthy of being called a conclusion; it's simply an observation of two very small data sets. The confidence bounds on the data for 25 August are essentially anywhere between

Pd = 0 and 1. Lateral range curves for life raft searches from other aircraft are provided in section 3.2 of Reference 3.

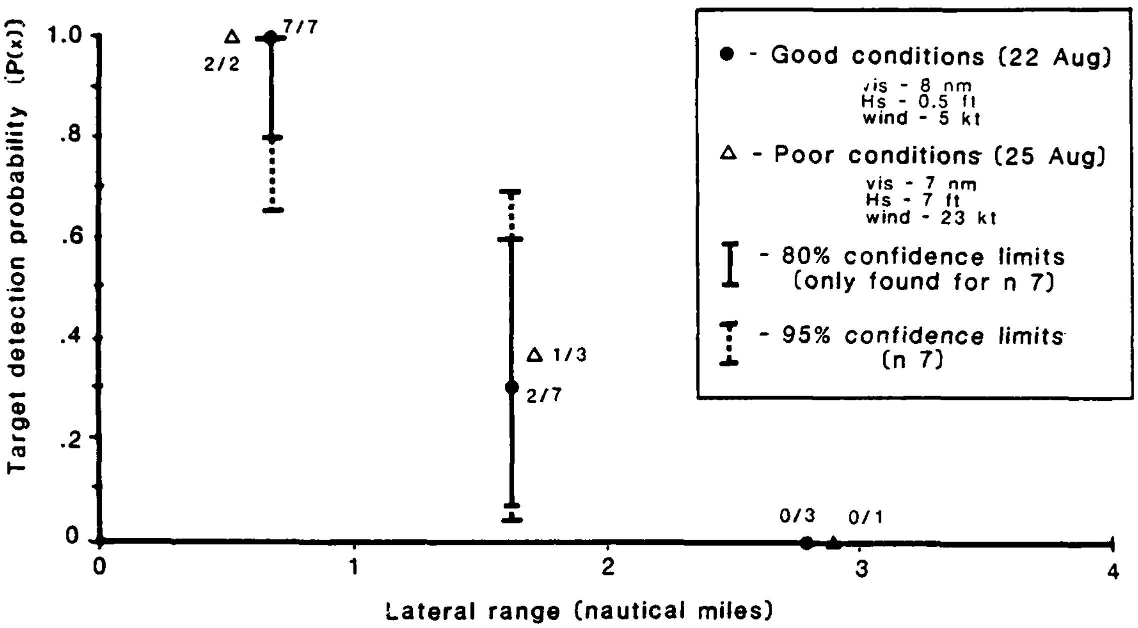


Figure 4-3. Lateral Range Versus Visual Detections of Life Rafts from an Airship

4.3 Electronic Search Performance

Although a night search using the installed Marconi IR Imager had been planned, the airship had not been cleared for nighttime operations by the British Civil Air Authority by the time these experiments were being conducted.

Although a surface search radar was available onboard the airship, there was insufficient time available during the five days allotted for the R&DC field test of the airship to permit an evaluation of its performance. On the one occasion that the radar was energized during the R&DC tests, it appeared to provide a stable and clear image.

4.4 Remote Site Recovery of An Airship

One of the potential uses of an airship is for the delivery/pickup of passengers (e.g. moving injured to a hospital) or parts to/from an unprepared remote site. To demonstrate this abilty, a series of recoveries/launches of the AI-500 was scheduled using an open field maintained by the National Park Service in Kitty Hawk, North Carolina. It seemed quite appropriate that the site selected for the landing had been used 80 years earlier by the Wright brothers for the first manned flight using a heavier-than-air vehicle.

On 25 August, after launching the airship at the Weeksville hangar, the ground support crew (i.e. 10 line handlers and a crew chief) drove to the Kitty Hawk field, with the mobile mast/support truck. It took approximately one hour to drive the 50 miles to the site. Although the truck would normally not be needed to complete the recovery, it was transported to the site in case conditions did not permit relaunching the airship or if refueling would be necessary.

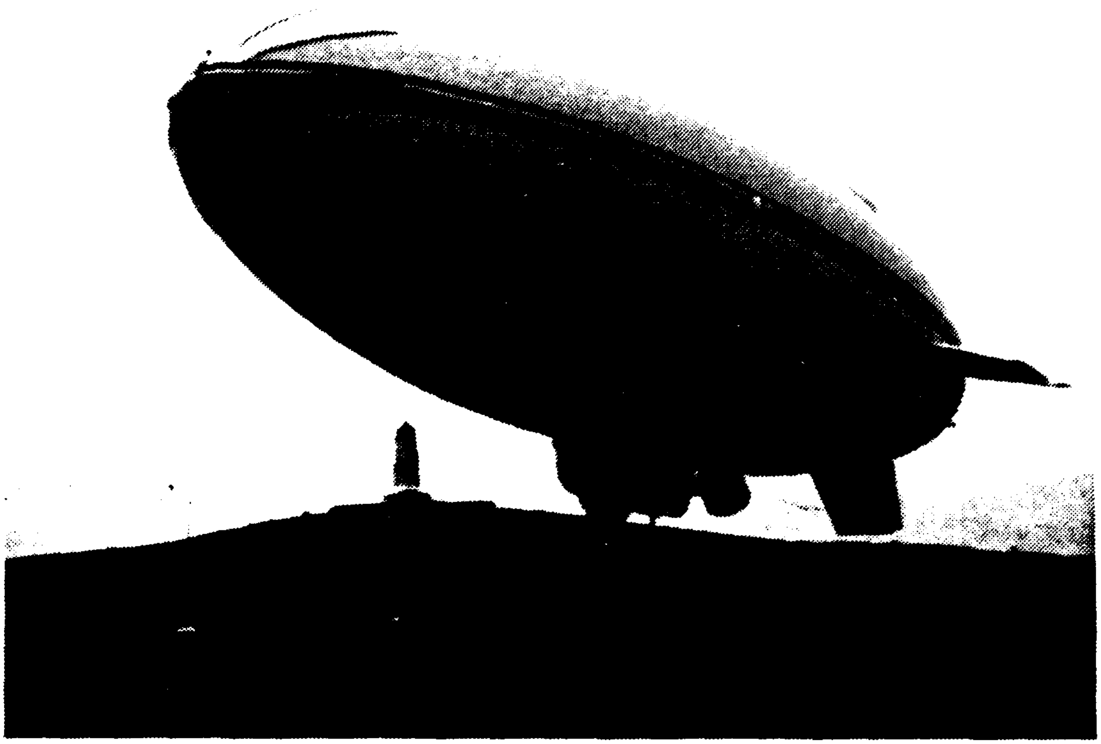


Figure 4-4. Airship Recovery at Kitty Hawk, NC

The airship arrived at Kitty Hawk at mid-day after completing a morning search exercise. It landed on its first approach, passengers were exchanged, and then the airship was launched for a short flight. After a second landing and passenger exchange, the airship returned to Weeksville (see Figure 4-4). Both recovery/launch evolutions were completed without incident in spite of a wind gusting to 25 knots. The ground support truck was not used. The ground crew left immediately after the second launch so as to arrive in Weeksville in time to recover the airship there. A large crowd of spectators was present at the Kitty Hawk site during the recovery exercises. These people were easily controlled and did not interfere at all with the airship operations.

The crew chief indicated that, in an emergency, the airship could be recovered with inexperienced ground handlers if an experienced crew chief were on scene and could provide about 15 minutes of training before the arrival of the airship.

4.5 Environmental Sampling Experiments

4.5.1 Remote Sensing

4.5.1.1 Subsurface Temperature Profiling

A total of four T-4 expendable bathythermograph probes were deployed from the AI-500. To operate, the T-4 probes require a ground connection with the ocean. These probes were designed for use from surface vessels where this ground is readily available. From an airborne platform, establishing a ground connection for the T-4 based system provides slightly more of a challenge. Other XBT probes specifically designed for use from aircraft do not require separate ground connections, but T-4s were selected for this experiment because they were readily available.

4.5.1.2 Thermal Imaging

The Marconi Thermal Imager was available for only one day of the test period. Since it did not provide absolute readings of ocean surface temperature, the device proved of only limited value for environmental survey applications. Although the Marconi system provided video recordings of the images taken during the day's experiments, the Marconi technical representative on-site for the tests maintained possession of these tapes thus preventing any further analysis of these data.

The real-time images observed during the flight provided excellent contrast and detail indicating that there is no reason to expect that devices similar to this (e.g., Forward Looking Infrared (FLIR)) would not function properly if installed on this airship.

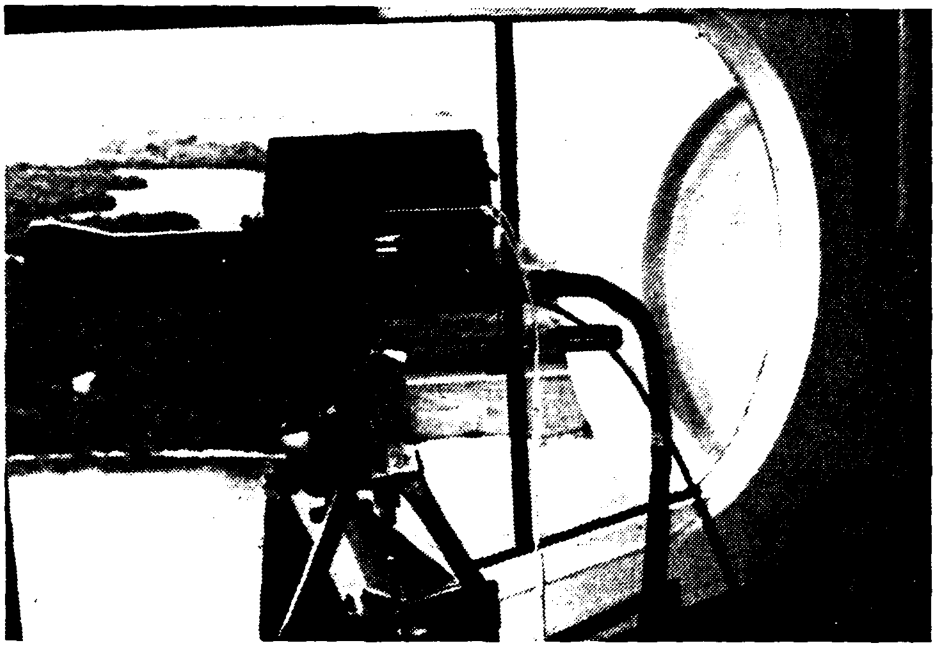


Figure 4-6. Marconi Thermal Imager

4.5.2 Sampling

4.5.2.1 Near Surface Gas Sample

This experiment was designed to determine if this airship could provide a suitable platform for the detections of vapors released from a moving surface vessel. It was anticipated that the ability of the airship to hover for extended periods and the relatively low production of turbulence were important attributes that would give this platform a distinct advantage over more conventional airships for this type of work.

The experiment involved the release of a tracer gas, SF_6 (sulfur hexafluoride) at a concentration of 10,000 ppm from the stern of a Coast Guard patrol boat (see Figure 4-7). SF_6 has been used in the past by many investigators in the tracking of stack emissions, fire gas movement, and to study general air flow patterns. This tracer gas is easily detected by gas chromatographic techniques. Brookhaven National Laboratories has successfully employed these techniques using fixed-wing aircraft to study the probable dispersion of radioactive gases released from offshore nuclear power plants.

Figure 4-7. Gas Release Apparatus Showing the AI-500 Airship Positioned Behind the Patrol Boat

No problems were encountered in drawing air samples at a rate of 19 liters per minute through tubing extending below the airship at levels of 10, 60, and 110 feet above the water surface. The airship was able to maintain stations for extended periods of time (total of approximately 70 minutes) behind a surface platform moving into the wind. This permitted the collection and concentration of large volumes of air. Multiple passes with a fixed-wing aircraft using large air sampling apparatus would have been required to conduct this same procedure. This volume of sampling would be required if low concentrations of released vapors were being monitored.

Efforts to determine the shape of the downwind vapor plume of SF_6 as well as existing concentration levels at various heights and distances behind the patrol boat were inconclusive. Several problems were encountered which prevented the accurate determination of SF_6 concentrations. The airship had not been available for the installation of the sampling equipment until the night before the test. Because the airship was not located adjacent to a suitable source of electric power (i.e. 110 VAC), a small gasoline powered generator was used during the set-up and calibration of the equipment. Serious interferences were immediately identified that caused poor detector response. Interferences similar to these had been encountered once before in a shipboard experiment designed to monitor the movement of SF_6. In this earlier case, the problem was traced to a defective carrier gas supply used by the gas chromatograph. However, when tested in the lab at the R&D Center prior to and after the airship tests, the system performed normally. It is believed that the fumes produced by the generator may have affected the system's performance. Although its performance (i.e. sensitivity response) improved during the morning of the test after a large volume of clean air was passed through it, interferences were still present (see figure 4-8). It appears highly probable that exhaust from the airship's gasoline powered engines contributed to this problem. Open windows in the gondola and an opening in the floor provided a path for engine fumes to enter the gondola, particularly during the long hover periods when new air was not being flushed through the gondola as occurs when the airsip is moving forward. This condition was simulated at the R&D Center after the airship tests using the exhaust from a portable generator. This produced similar results to those encountered during the airship tests, but not of the same magnitude.

Figure 4-8 shows some of the sample gas chromatograph traces related to this exercise. The first trace is from a test conducted in the lab at the R&D Center demonstrating that a sample could be taken through 120 feet of teflon tubing. The first peak with the .68 minute detection envelope is the SF_6 gas. The second peak (i.e. 1.02 minute detection envelope) is the major air component. The middle trace was obtained during the set-up of the analytical system on-board the airship. This shows a large negative spike just before the first positive spike (i.e. .52 minute detection envelope). Both of these apparent anomalies may have been caused by a combination of impurities in the carrier gas used in our gas chromatograph and the apparent presence of a background gas (i.e. CO) in the airship gondola during the sampling period. The SF_6 envelope was completely masked by these responses during this sample. The .78 minute peak is the major air component and the 1.24 minute peak represents other background gases. The final trace was obtained at a sample level about 5 meters above the ocean surface with the airship about 50 yards astern of the surface boat releasing the gas. It shows a weak detection of SF_6 indicated by the .43 minute detection envelope. This is partially masked by the .51 minute impurities envelope and followed by the major air component envelope (i.e. .78 minutes).

(The magnitudes of the retention times are dependent on the flow rate and the integration start time.)

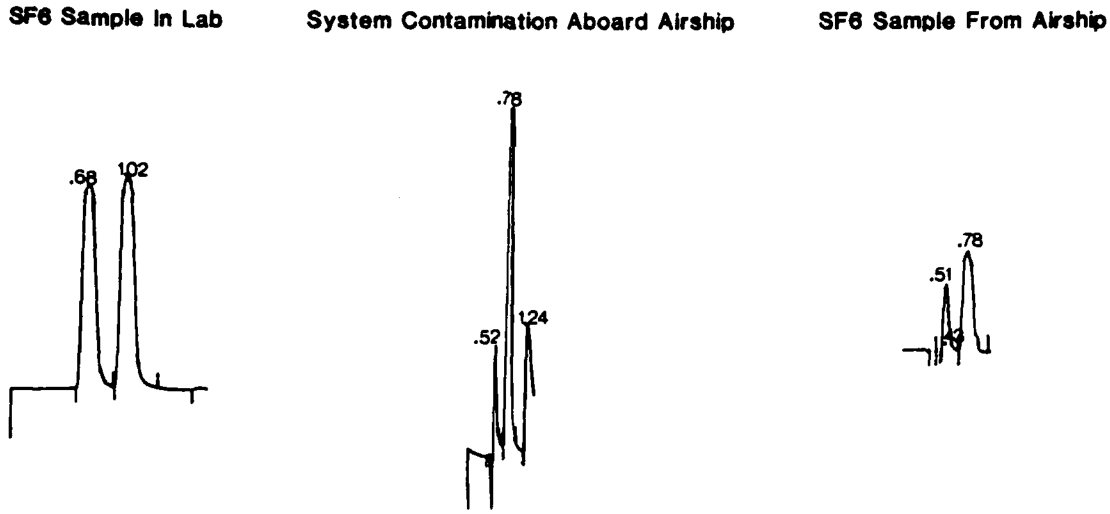


Figure 4-8. Gas Chromatograph Traces

4.5.2.2 <u>Water Sample</u>

A 1.7 liter Go Flo sample bottle was lowered into the water from an altitude of about 25 meters using a 1/4 inch (6.35 mm) line. Once submerged in the water, closure of the bottle was triggered by sliding a 400 gram weight (i.e. messenger) down the line. The bottle was lowered and recovered by hand through the floor opening. This surface water sample was recovered without incident. Neither the bottle nor the line was affected by nor interfered with the operation of the airship. A small winch would have proven helpful in retrieving the sample, but not necessary.

Figure 4-9. Go Flo Bottle Being Recovered from the Ocean

4.5.3 Air Deployment/Recovery

This section discusses the results of experiments designed to identify any problems associated with the dropping of a variety of objects from an airship and the capability of recovering small objects floating on the ocean surface. The objective was to identify any problems associated with prop wash, near-hull turbulence or other peculiarities that would preclude this type of operation.

4.5.3.1 Datum Marker Buoy (DMB)

The buoy was dropped from the portside window at approximately mid-gondola from an altitude of 200 feet. The buoy dropped straight down showing no signs of interference by the airship. The parachute filled and the buoy entered the water without complication. The transmitter on the buoy was activated just prior to deployment and was indicating (by an indicator light) that a signal was being transmitted. A directional receiver was not installed on the airship, thus the buoy's operation after entering the water could not be confirmed. The buoy was recovered by the CGC POINT BROWN immediately after a series of recovery attempts from the airship. When returned to the dock and inspected approximately 5 hours after the drop, the buoy was no longer transmitting. It could not be determined whether the buoy failed during deployment or sometime after it entered the water during recovery. These buoys have well known reliability problems.

4.5.3.2 Drift Cards

The drift cards were deployed from the main gondola access door on the airship's port side. The port side fan was idled during deployment. The cards dropped freely well clear of the ducted fans sailing down to the ocean surface without complication. Deployment altitude was approximtely 35 meters. A total of 3 cards were released along a west to east (offshore) line.

These cards provide a method for determining surface current through a temporal record of their position. Periodic position marks using the microwave tracking system were obtained each time the airship passed directly over the cards. Approximately 35 minutes was spent in the vicinity of drift card #2 while conducting Expendable Surface Current Probe (ESCP) experiments. This provided several opportunities for marking the position of card #2. Drift card #1 was not resighted after a position check shortly after initial deployment. The first attempt to relocate this card was not made until 4 hours after this initial sighting. A post-experiment reconstruction of the airship's search pattern when looking for card #1 indicated that it did not search the most probable location for the card based on the observed drift experienced by the other two cards. Card #1 was predicted to have drifted 7.5 kilometers in the 4 hours, much farther than anticipated by the observers on board the airship when developing a search track for card #1.

The average speed and direction observed for drift card #2 was .9 kts toward 183°T. Individual short-term speeds varied between .8 and 1.3 knots. The speed and direction of drift card #3 averaged .95 kts toward 171°T. Both these cards were observed over approximately a 3-1/2 hour period. Figure 4-10 shows the drift track recorded for these drifters.

The safety of this exercise would have been enhanced if a better attachment had been available on the airship to fasten the safety harness used by the crewmember who was required to partially hang out the gondola door to drop the cards.

4.5.3.3 Expendable Surface Current Probes

During the two days available for environmental sampling experiments, a total of five expendable surface current probes (ESCPs) were deployed from the airship at altitudes between 500 and 1000 feet. In each case, the parachute opened as designed and the ESCP fell freely to the ocean surface, experiencing no interference from the airship nor interfering with the airship operation. (The airship's fans were stopped at the time of the deployment.) The ESCPs were dropped from a portside window near mid-gondola. Four of the five probes operated without flaw, each providing three dye traces on the ocean surface. The fifth probe released only two floats, meaning that, most likely, the last of the three floats became lodged in the ESCP deployment tube as it lay on the ocean floor.

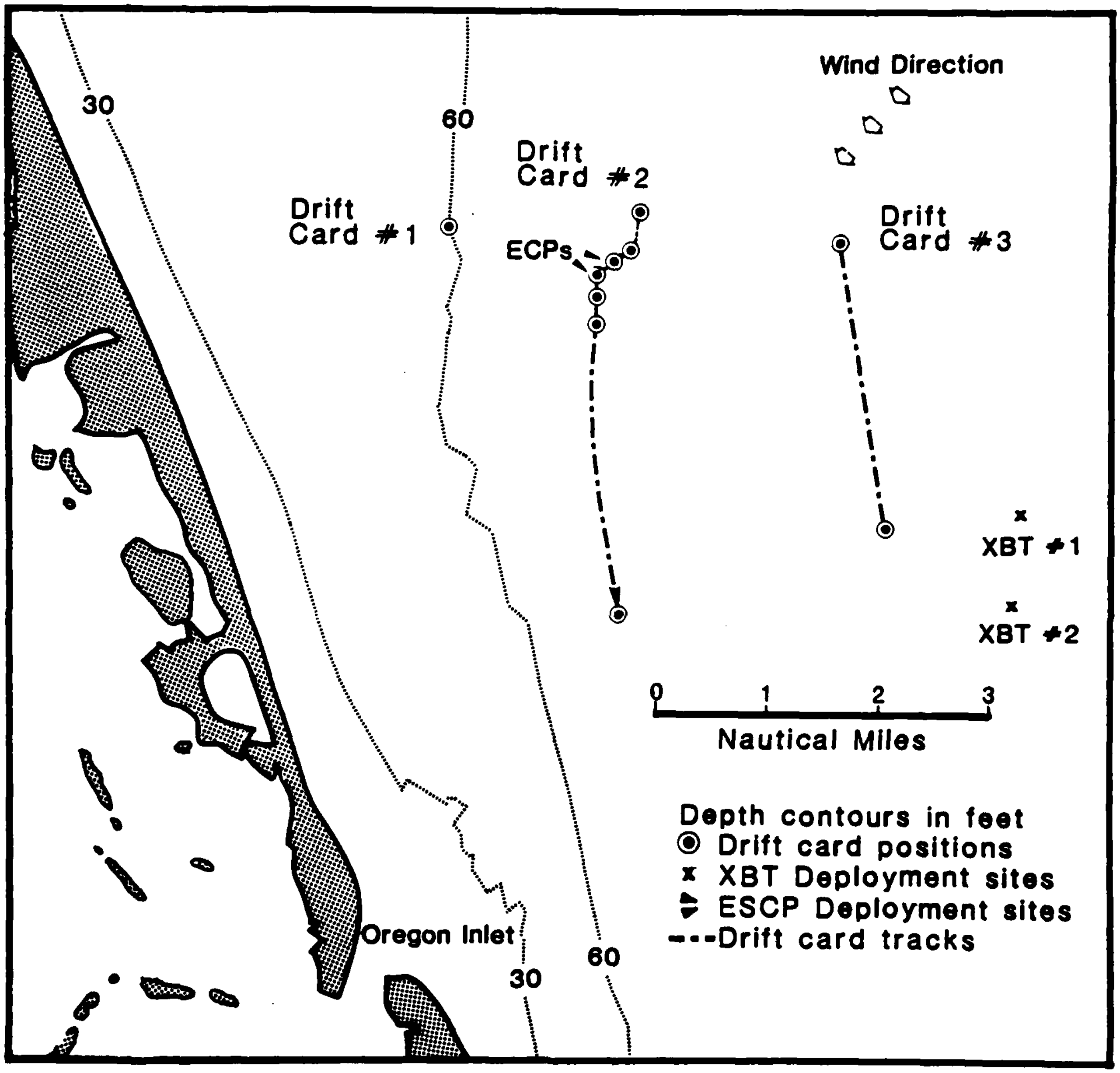


Figure 4-10. Drift Card, XBT and ESCP Deployment Sites and Drift Card Tracks as Observed from the AI-500 Airship on 26 August 1983. Drift Card #1 was released at 1039 and not resighted, Drift Card #2 was released at 1046 and last resighted at 1429, and Drift Card #3 was released at 1053 and resighted at 1424.

In the ESCP and drift card experiments, vertical photographs were taken using both 70mm Hasselblad and 35mm Pentax cameras. For the majority of the shots, the Hasselblad cameras were securely attached to the airship frame through an adjustable arm positioned over the hole in the gondola floor allowing for vertical photographs. Hand-held shots were also taken with both the 70mm and 35mm cameras. No problems were encountered. Shots were taken at a variety of speeds and aperture settings with both color and black and white film. Photographs obtained were generally sharp with no distortion apparent beyond that inherent in the lenses used. Some blurring was detectable in the slow shutter speed black and white photos.

Two photographs of the float's dye traces from the second probe released on 26 August are shown in Figure 4-11. This probe was dropped next to Drift Card #2 in the position indicated in Figure 4-10.

The experiments successfully demonstrated the ability to release a probe of this general character from an airship. One weakness of this particular current measuring technique is that the floats are exposed to different currents due to the time difference in their release. The importance of immediately measuring the distance between the floats after their first appearance on the surface is indicated by the differential drift experienced by the floats shown in Figure 4-11. In this example, the current calculation made based on the separation of the floats after 25 minutes of motion (bottom photo) indicated a current magnitude 50% smaller than more accurate measurement made shortly after the floats appeared and verified by the measured absolute movement of the drift card located in the immediate vicinity of the ESCP floats.

The distributions shown in this figure depict the relative motion of the ESCP floats and drift card #2. Photographs were taken from an altitude of 1000 feet using a 50 mm lens on a 70 mm aerial camera. The surface current was determined by measuring the distance between floats #2 and #3 and then dividing by the time difference between their release from the bottom (i.e. 72 seconds). It is obvious that floats #2 and #3 drifted at different speeds after surfacing. This indicates the importance of measuring the float separation immediately after the last float appears at the surface to reduce the error in the current calculation caused by differential drift. The fact that the airship can maintain station over the ESCP deployment position is an important advantage.

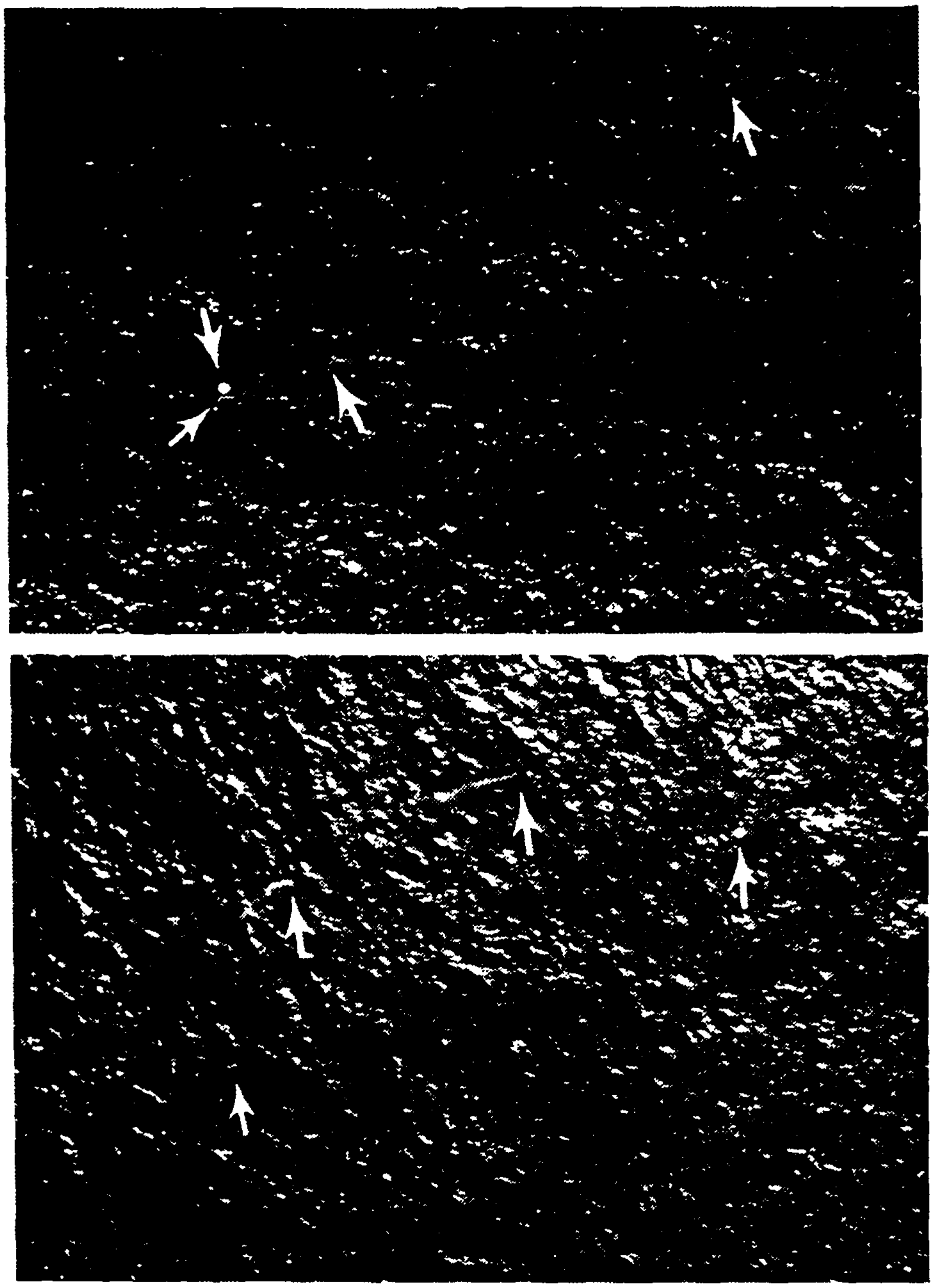


Figure 4-11. Photograph of the ESCP Dye Traces Showing Drift Card #2 and the Three ESCP Floats. The first photograph was taken shortly after the third float appeared on the surface at 1114 local time. The second photograph was taken at 1139 local time. Drift Card #2 drifted approximately .7 km to the SSW between the time of the first and second photographs.

4.5.3.4 Attempted Recovery of Floating Objects

In an effort to demonstrate an airship's ability to recover objects floating on the ocean surface, several attempts were made to recover a datum marker buoy (DMB) using a small grappling hook (i.e. 25 cm diameter) suspended on a line through the floor of the AI-500. To increase the effective size of the target, a loop of polypropylene line had been attached to the DMB prior to deployment. Unfortunately this line balled up around the buoy during deployment, reducing the size of the object to be recovered from the intended 2 meter diameter loop to a ball approximately 30 centimeters in diameter. A total of 4 unsuccessful attempts were made to recover this buoy from an altitude of about 20 meters while experiencing a wind of approximately 15 knots. If the loop had deployed as intended, the buoy would have most likely been recovered on two of the four attempts. The maneuvers were complicated by the need to drag the hook across the target using the motion of the airship (i.e. casting the hook was not possible) and by the fact that the pilot could not see both the hook and the target as they approached each other. It was very apparent that pilot technique was a big factor in the success of maneuvers of this type. The pilot of the airship for this exercise was experienced and very competent. A less experienced pilot would most likely not have come as close to recovering the buoy.

The AI-500 does not represent state-of-the-art design for precision hover work. A bow and stern thruster would have greatly increased the ease of this type of maneuver. Not having these, the AI-500 tended to slide off the target as its nose fell off the wind.

4.6 General Platform Strengths and Shortcomings Identified During the Experiment

4.6.1 Strengths

Many of the preconceived strengths were substantiated during these tests. These included the following:

-Proved to be a stable platform with low vibration and a comfortable ride.

-Offered excellent visibility with large single piece windows.

-Provided for easy deployment of a large variety of devices with no interference from or to the operation of the ducted fans.

-Proved capable of supporting the operation of a large variety of sensors both electronic and photographic.

-Experienced no difficulties with the launch or recovery of the airship either from its main base or from a remote site.

-Capable of operating at low altitudes (i.e. below 20 meters) without complication or consternation.

-Demonstrated ability to interface with the ocean surface without complication.

4.6.2 Shortcomings

A few shortcomings were identified with the AI-500 that affected the suitability of this platform for search and MSA missions. Several of these problems could be corrected with only slight modification to the AI-500, others would require employing a larger and more powerful airship. The following list includes problems that have not been discussed or only partially discussed earlier in the report.

o Weight limitations: The relatively small size of the AI-500 coupled with a loss of lift due to a helium purity problem proved to present significant weight limitations. These restrictions affected the scope of a few of the test and evaluation experiments that had been planned (e.g. preventing the onloading of some equipment and researchers.) The purity problems persisted throughout the test reducing both payload capacity and operating speed (i.e. more thrust was needed to provide dynamic lift to compensate for loss of static lift). Had the mobile purifier intended for use during these experiments not been damaged in shipment and thus been available for use, or if its availability had not been planned around (i.e. would not have entered envelope as many times in early parts of the experiment), a high level of helium purity probably could have been maintained. Purity of 99% was planned, but this had dropped to 95% by the latter part of August. It is interesting to note that airships operated in the 50's averaged a helium purity of about 92%.

o Endurance: The 12- to 14-hour endurance projection was not realized, partially because of the reduced fuel load required to compensate for static lift loss and partially because of pilot fatigue caused by the lack of power assisted controls and automated steering devices (e.g. autopilot).

o Speed: Although the AI-500 was theoretically capable of a maximum speed of 55 knots and actually obtained speeds slightly higher than this during the NADC tests, the average indicated air speed obtained during the R&DC segment of the tests was approximately 35 knots.

o Ground handling: The latest and best ground handling techniques were not employed during these tests. Airships Industries, Inc., was admittedly not out to display state-of-the-art ground handling. Although the increased maneuverability and power of this airship did result in the reduction of the required ground crew compared to many of the rigid and non-rigid hulls of 30 to 40 years ago, the recovery and release techniques were essentially the same. Equipment developed by the U.S. Navy in the late 50's reduced the size of the ground crews required for the 120 meter non-rigids to about 18 and if similar equipment had been employed for the AI-500, ground crews of only 2 or 3 persons would probably have been required.

o Creature comforts: For long endurance flights, the airship would need toilet facilities and a minimally equipped kitchen area. Climate control is also necessary for operations in tropical or semi-tropical regions or during summer operation in the north.

o Backfiring: On those occasions when the airship was required to maintain a hover over a fixed point for an extended period of time (i.e. greater than about 5 minutes) in other than very low wind conditions, the gasoline engines used to power the propulsion fans tended to backfire. Although it was not a particularly dangerous situation, it did cause some concern when it first occurred.

o Operations in adverse weather: Although new materials provide for a theoretically stronger airship than those of the past and airships have been operated safely in severe weather (e.g. thunderstorms), there was still great reluctance to operate the AI-500 in potentially turbulent weather. On 23 August, airship experiments scheduled for the open ocean area off Oregon Inlet were cancelled because of predicted storm front passage and thunderstorm development in the area. The pilot was concerned that if the airship proceeded to the coast it may not have been able to safely return to Weeksville after the exercises because of blockage by the front. The airship was used for other experiments over the river water off Elizabeth City on that day.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 Conclusions Regarding Airship Search Performance

o The AI-500 proved to be an excellent platform for visual searches of small objects on the surface of the ocean offering among many advantages: good visibility, generally comfortable environment, relatively long on-scene endurance, low altitude and a modest range of search speeds. In searches for persons-in-the-water, detection data collected during these experiments indicate that on-board searchers can obtain comparable and potentially better detection performance when searching for small objects on the ocean surface than they would on the more conventional aircraft presently available within the Coast Guard.

o The AI-500, while incorporating many state-of-the-art design features and new materials, was found to be too small for practical use on search missions. Payload, speed and endurance limitations would prove too restrictive. Although not ideally suited for this task, the following modifications to the AI-500 would produce a significantly improved platform for lengthy searches over open ocean:

-Power assisted controls and an autopilot interfaced into better navigational equipment (e.g. Loran, Inertial Navigation, Satellite Navigation)

-Additional creature comforts (e.g. toilet facilities, a galley area for food preparation and cold storage, and air conditioning)

-Use of electronic search equipment (e.g. Forward Looking Infrared (FLIR), radar, Active Gated Low Light Television (AGTV))

-Better internal and external communications equipment

-Lower cut windows to provide better down look

5.1.2 Conclusions Regarding Use of Airships as Environmental Sampling Platforms

o In general, there were no peculiarities or uncorrectable problems identified during these tests that would prevent the use of this platform for the employment of a wide variety of sampling devices, techniques and sensors.

o In addition to the weaknesses listed in the previous section, the following correctable problems related to environmental sampling from the AI-500 airship have been identified:

-Problem with exhaust fumes in the gondola after extended hovering operations. Better ventilation or a climate control system in a pressurized gondola compartment would eliminate this problem.

o The conduct of a meaningful ocean survey with the objective to provide synoptic samples of sizeable ocean areas. This effort would evaluate any difficulties identified with the real-time analysis of environmental data collected from an airship and the transmissions of these data for input into operational systems (e.g. Computer Assisted Search Planning (CASP)).

REFERENCES

1. Bailey, D.B. and H.R. Rappoport. Maritime Patrol Airship Study (MPAS). Report No. NADC-80149-60. U.S. Naval Air Development Center and Summit Research Corporation (19 March 1980).

2. Bailey, D.B., et al. Patrol Airship Concept Evaluation - Cooperative Study. In preparation by U.S. Naval Air Development Center (1984).

3. Edwards, N.C., Osmer, S.R., Mazour, T.J., and Hover, G.L. Factors Affecting Coast Guard SAR Unit Visual Detection Performance. Report No. CG-D-09-82. U.S. Coast Guard Research and Development Center and Analysis and Technology, Inc. (August 1981).

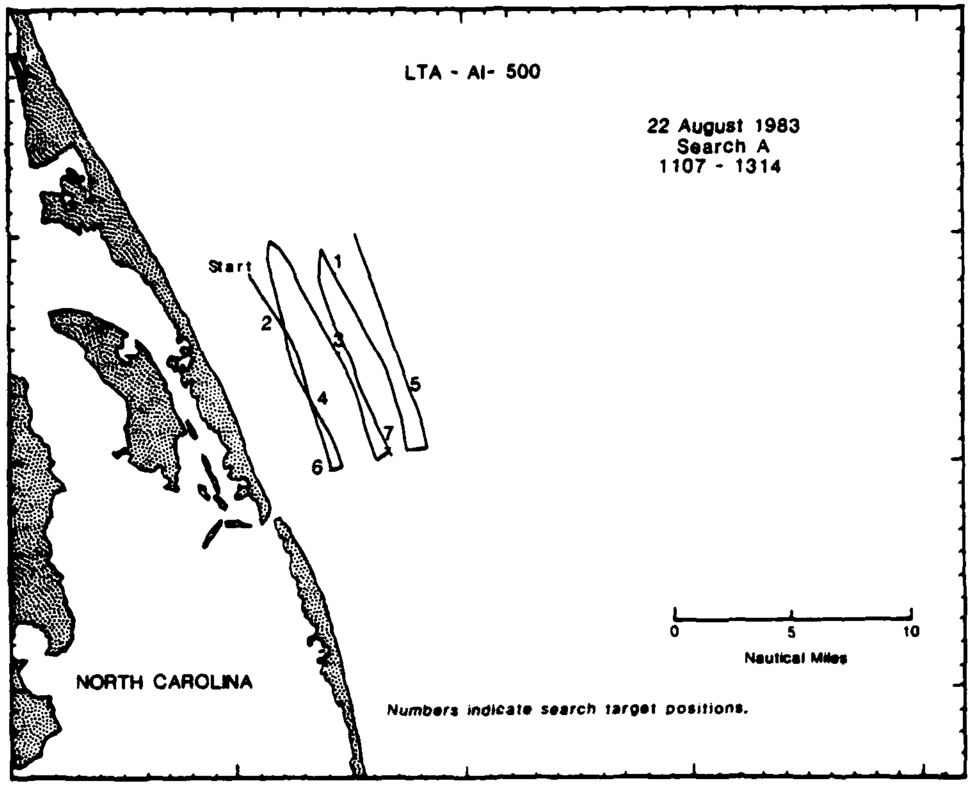
4. *U.S. Coast Guard. R&DC Test Plan: Airship Proof-of-Concept* Evaluation (Visual and MSA) (August 1983).

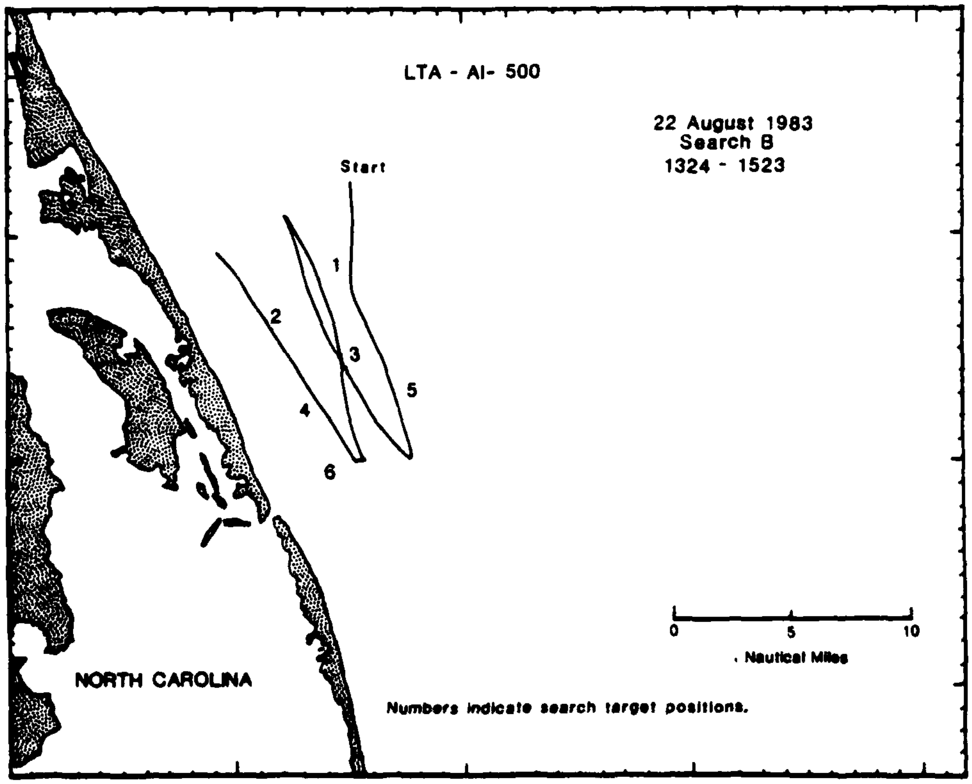
5. U.S. Coast Guard. National Search and Rescue Manual. COMDTINST M16130.2 (1982).

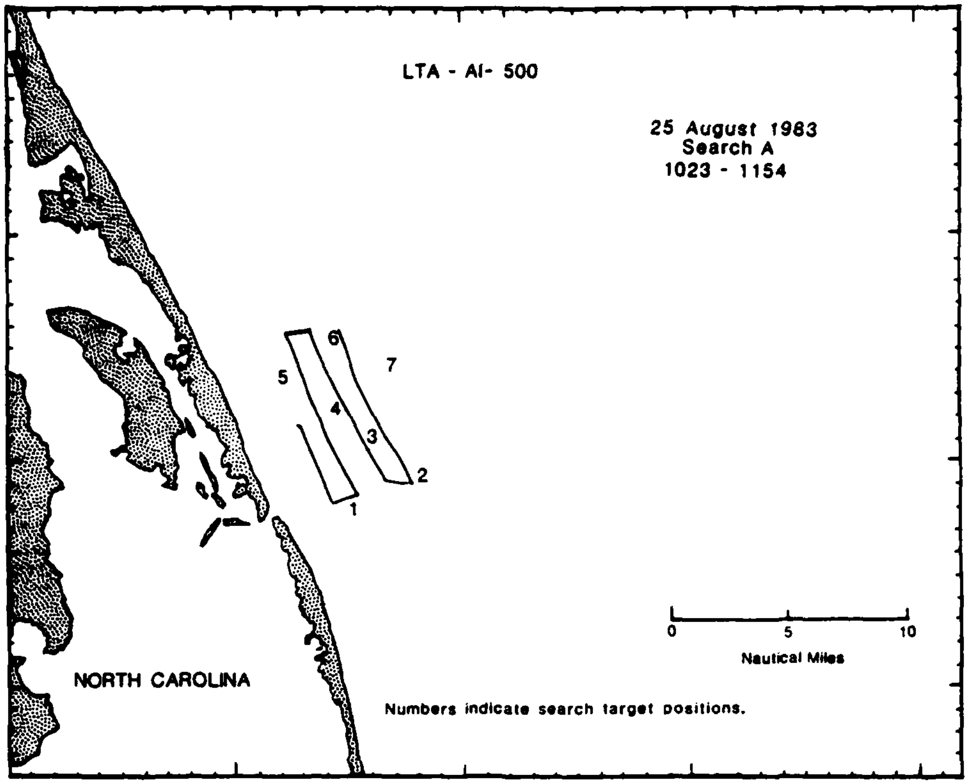
6. *Richardson, W.S., H.J. White, Jr., and L. Nemeth, 1972. A Technique for* the Direct Measurement of Ocean Currents from Aircraft. Journal of Marine Research, 30 (2): 259-268.

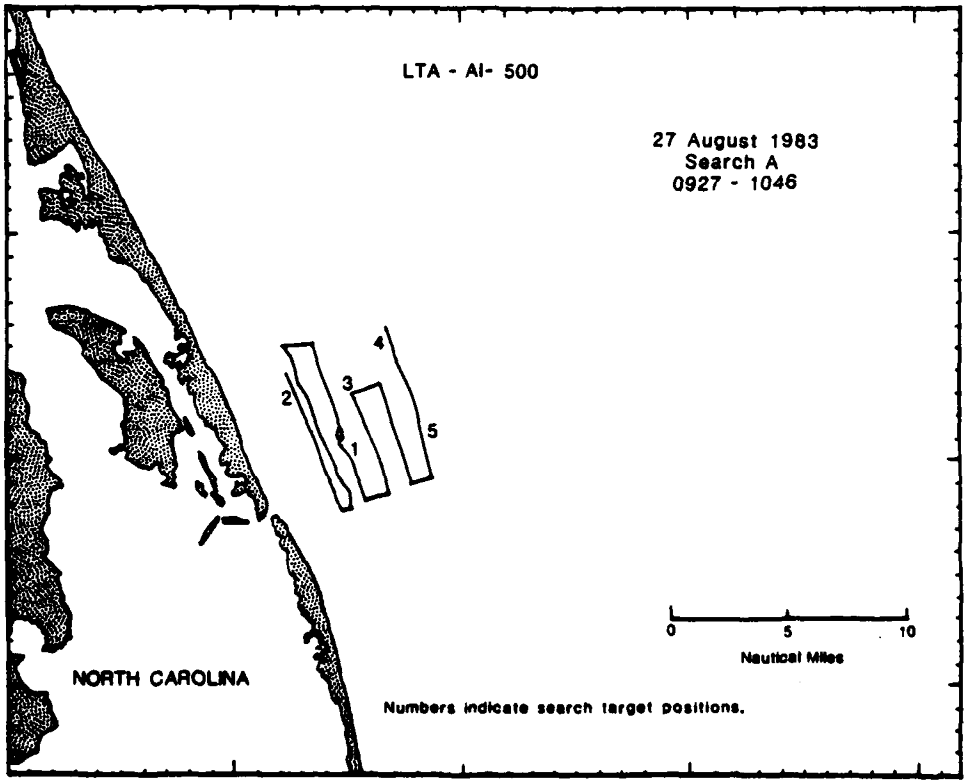
APPENDIX A
AIRSHIP VISUAL SEARCH TRACKS

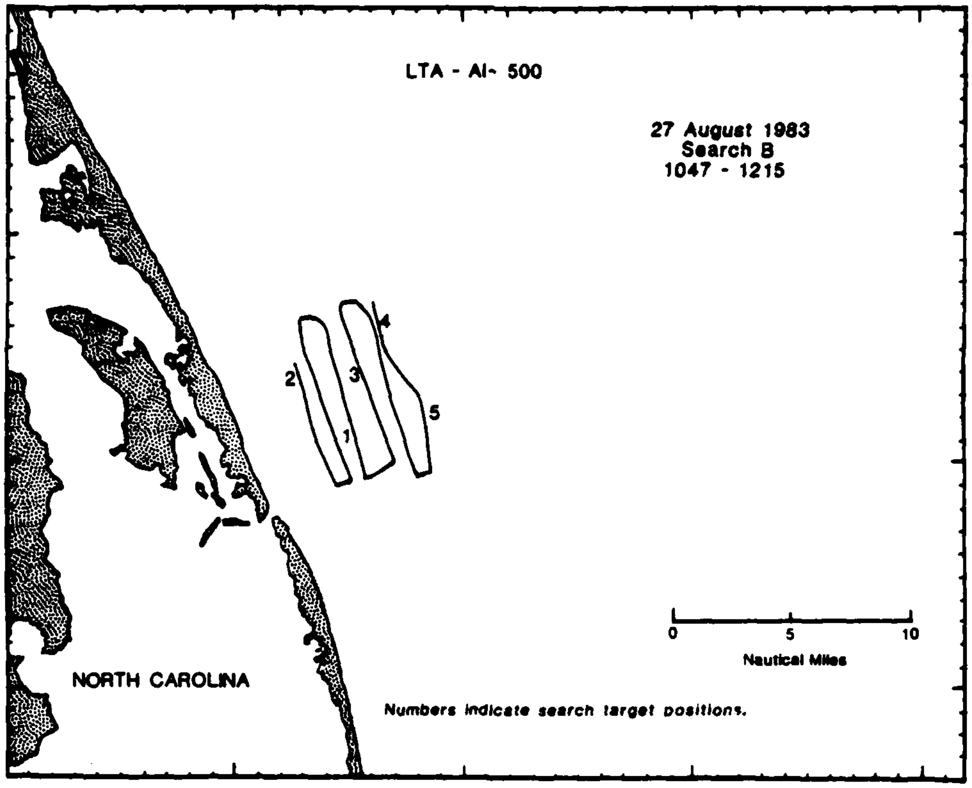
The figures provided on the following pages show the tracks completed by the AI-500 on the three days it was used for search exercises off Oregon Inlet, NC. Airship positions were determined and recorded by the Microwave Tracking System (see Section 3.2.1.2). The presentations shown are identical to those that appeared real-time on the CRT display for the researcher's use in the Operation Center at Oregon Inlet.

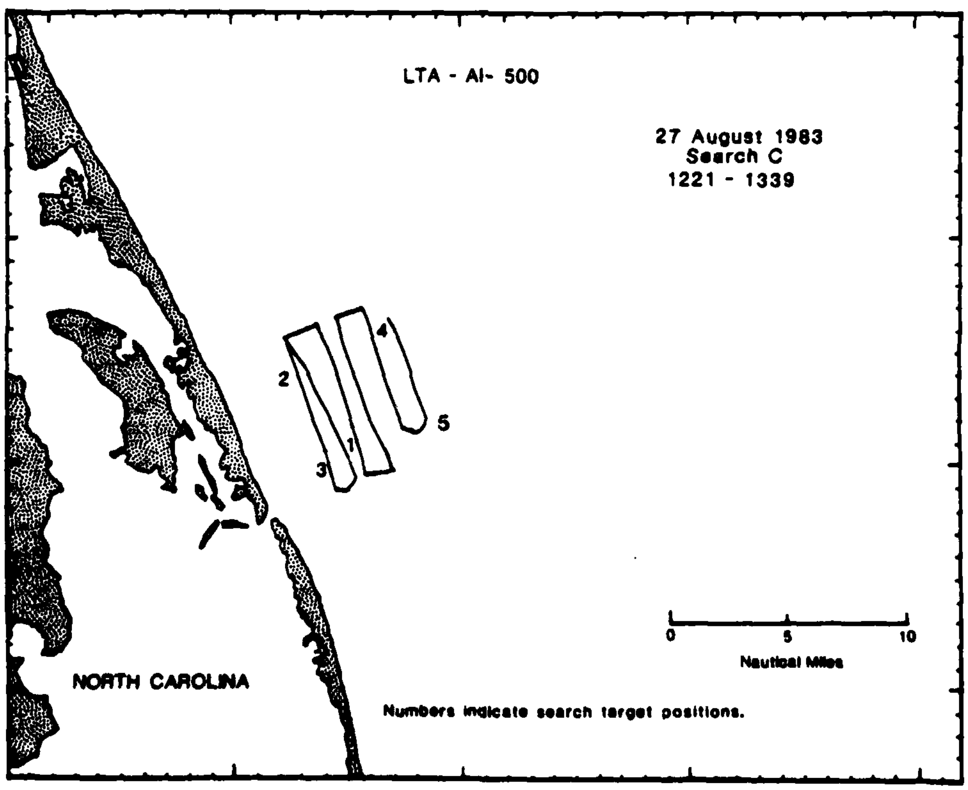

LTA - AI- 500
22 August 1983
Search A
1107 - 1314
Start
1
2
3
4
5
6
7
0
5
10
Nautical Miles
NORTH CAROLINA
Numbers indicate search target positions.


LTA - AI- 500
22 August 1983
Search B
1324 - 1523
Start
1
2
3
4
5
6
0
5
10
Nautical Miles
NORTH CAROLINA
Numbers indicate search target positions.


LTA - AI- 500
25 August 1983
Search A
1023 - 1154
1
2
3
4
5
6
7
0
5
10
Nautical Miles
NORTH CAROLINA
Numbers indicate search target positions.


LTA - AI- 500
27 August 1983
Search A
0927 - 1046
1
2
3
4
5
0
5
10
Nautical Miles
NORTH CAROLINA
Numbers indicate search target positions.


LTA - AI- 500
27 August 1983
Search B
1047 - 1215
2
3
4
1
5
0
5
10
Nautical Miles
NORTH CAROLINA
Numbers indicate search target positions.


LTA - AI- 500
27 August 1983
Search C
1221 - 1339
2
4
1
3
5
0
5
10
Nautical Miles
NORTH CAROLINA
Numbers indicate search target positions.

APPENDIX B
COAST GUARD OBSERVER COMMENTS

Briefings and debriefings were provided for all exercise participants immediately before and after each flight. The pre-search briefing served to set the tone for the search operation, establish data report procedures and review exercise objectives. Debriefing allowed participants to express their opinions about airship performance compared to other platforms with which they were familiar. Comments from these participants are presented below with an indication of the seniority and experience of each observer. Observations expressed by R&D Center Field Team members have been incorporated into the body of the main report.

Observer	SAR Experience	Date of Airship Flight
LTJG	10 years	22 August
AM1	17 years	22 August
AD1	12 years	22 August
LCDR	5 years	25 August
AT1	6 years	25 August
AD2	8 years	27 August
CWO2	20 years	27 August

Visibility

LTJG — Excellent Field of View (FOV) - Cut windows down lower so FOV close-in is achieved without hunching over seat.

AD2 — Large windows allow scanner to see targets even when looking cross-hull.

AD1 — Lots of viewing area and slow speed are good for search.

AM1 — Excellent FOV and visibility. Picked up some glare at low sun angle.

LCDR — Windows are too high. They need to be cut lower.

Comfort

AD2 — Comfortable ride.

AD1 — Comfortable ride. Would prefer airship to C-130 for long searches.

LCDR — Noise and vibration would rival an HH-52.

ATC — Vibration during tight maneuvers may cause problems.

LTJG — Vibration and noise should and could be reduced.

AM1 — Interior noise level should be reduced.

ATC	Fairly noisy, but not unbearable.
AD2	The helium envelope provides a good shade.
AD2	It was nice to have good air flow.
AM1	A relief tube is essential.

Performance

LTJG	Need to increase dash speed to 90 kts.
LTJG	Does everything a helicopter can do, plus it has great endurance.
AM1	A good, permanent internal communication system is needed.
AM1	A variable speed hoist is needed on mount that provides good visibility for operator.
ATC	Not enough power.
ATC	Too small and too little power.
ATC	Pilot worked hard.
LCDR	Rides like a sailboat.
LCDR	Hard to maneuver - like tacking with a sailboat.
ATC	Pitch should be a concern. It was up to 15 degrees and more at times.
LCDR	Pilot was extremely skilled and worked very hard (was very fatigued after 4-hour flight in 24 kt winds).
ATC	Yaw caused airship to be up to 30 degrees off course at times.
ATC	No roll.
ATC	Loran-coupled INS would be very helpful.
ATC	Needs to have power assisted steering.
LCDR	In 24-knot winds, had difficulty hovering (HH-52 would not have this problem).
LCDR	The configuration of the controls in the cockpit were unsatisfactory. Rudder pedals and yoke mounted engine controls would help.
LCDR	RADALT or Doppler are needed (something to give accurate ground speed).

LCDR	It was nice to be able to stick your head out of the window.
LCDR	There were no attachments available for the safety harness in the cabin.
AD2	The slower search speed was easier on the eyes (flash by of waves) and enables longer fixation times.
CWO2	The 200-foot search altitude seems to be better for detections.